THURSDAY, JULY 27, 1899.

INORGANIC CHEMISTRY.

Lehrbuch der Anorganischen Chemie. Von Prof. Dr. H. Erdmann. Pp. 728. (Brunswick: Vieweg und Sohn, 1898.)

THIS book is based upon the well-known work of Gorup-Besanez, the last edition of which was published in 1878, but it is practically a new book. It is printed in the style of Roscoe and Schorlemmer's treatise, handsomely illustrated, and well bound. In the 728 pages a vast amount of information is given about the facts of inorganic chemistry, and this information is in most respects well abreast of the time. The treatment and presentation of the subject are quite orthodox, except in so far as the description of experiments and of technical applications is separated from the main text, and printed in smaller type after the more general and descriptive account of a substance or group of substances has been written.

It is, perhaps, asking a good deal that a new book on inorganic chemistry should differ much except in size or price from contemporaneous works on the same subject. A perusal of the present work proceeds without any sense of freshness until the sections on helium and argon, where for the first time the personal authority of the writer is felt and approving interest excited. After this the even tenor is resumed until the second part of the work dealing with the metallic elements is reached. Here again interest is aroused, and the author may be congratulated on having produced a very readable account of what, scientifically speaking, is usually the dullest part of a book on inorganic chemistry. The accounts of technical applications which are intercalated in the text are very well written, interesting, and trustworthy.

The chief question raised by this book is how far theory is to be introduced into a book on inorganic chemistry. Is a book on inorganic chemistry to be a compendium of facts, whilst the theory is to be sought in books on general or physical chemistry? As a matter of fact, books on inorganic chemistry written up to about 1870 included a discussion of all that was known of theoretical and physical chemistry. Till then the only important quantitative laws that were clearly established referred to composition, and accordingly the theoretical part of such books dealt mainly with the laws of chemical combination and the atomic and molecular theories. But things have advanced since then; we now know a great deal about chemical dynamics, and it seems anomalous that in such a book as the one under notice there should be no general exposition of the laws governing chemical reactions and chemical equilibrium. These laws, like the laws of composition, are fundamental, and the light they throw on every-day inorganic chemistry is indispensable for a right apprehension of the facts. There seems no good reason for neglecting them in a book of 700 pages dealing with inorganic chemistry.

The theoretical part of the book is also in other respects the least satisfactory feature. It displays much of the anxious striving, to which some minds seem peculiarly liable, to be fundamental and logical on points where such exercitation is quite unnecessary and unfruitful. An advanced student surely does not need to be carefully initiated into the difference between Roman and Arabic numerals, or the meaning of 10^6, or the impossibility of putting a quart of liquid into a pint pot; yet these and like matters are gravely and lengthily expounded. The effect is to submerge the salient points of doctrine in a sea of tedious disquisition. One cannot but wish that the space so used had been saved for the discussion of such important theoretical matters as the constitution of ozone, the hydration of salts, the absorption of hydrogen by metals, the atomic weight of tellurium—topics to which justice is not done in the book.

There are some omissions and a few mistakes in the book. The account of flame includes the apparently ineradicable dogma that the hydrogen of a hydrocarbon burns preferentially to the carbon, and that solid particles of carbon are burnt up in the mantle. The rate of the explosive wave is confused with the velocity of inflammation, and the acetylene flame, which readily melts a platinum wire, is stated to be peculiarly cool. The blemishes in the book on matters of fact are, however, not many; the information is indeed, on the whole, admirable, and we have no doubt that Prof. Erdmann's work will on this account meet the requirements of a large class of students.

A. S.

MARINE BOILERS.

Marine Boilers. By L. E. Bertin; translated and edited by L. S. Robertson, with a preface by Sir William White, F.R.S. Pp. xxviii + 437. (London: John Murray, 1898.)

THIS is a translation, with some important alterations and additions, of M. Bertin's well-known work on marine boilers. M. Bertin, now Director of Naval Construction for the French Navy, was previously Principal of the *École d'application du Génie Maritime*, and his text-book was the outcome of the course of lectures on boiler construction which he delivered to the students of that institution.

The work has been translated by Mr. L. S. Robertson, an authority on the so-called water-tube boiler, and has the advantage of a graceful tribute to M. Bertin's skill as an engineer and naval architect in the form of a preface by Sir William White, Chief Constructor to the British Navy.

The book is copiously illustrated, but unfortunately the plates are sometimes by no means clear, and where dimensions are given it is often impossible to read them; as the illustrations are reproductions of those in the original French work, the dimensions are in metric units, while all the dimensions in the text have been converted into English units. Fewer illustrations, more clearly reproduced, would have been an improvement; though these remarks apply in the main to the general drawings only, the detail drawings being much clearer.

The author has divided the book into four parts, and has covered fairly completely the whole field. Part i. is devoted to the important subjects of combustion, trans-

mission of heat, corrosion, &c., and to the various methods for producing draught, with a discussion of the advantages and disadvantages of the various systems.

On p. 45 there is a slip, probably arising in conversion of units: it is stated that 5·89 lbs. of oxygen are needed to burn a pound of carbon; the figure should be 2·67 lbs. In discussing the possibility of the utilisation of the heat passing away up the funnel for warming either the feed water or the air before it passes into the furnace, there is a somewhat curious remark about the heat wasted in condensing the exhaust steam from an engine by cold water in the condenser, the author stating that so far "no remedy for this evil" had been proposed. Surely it has been forgotten that since the engine can only convert into work a small portion after all of the heat it receives, there must be rejection of heat in the condenser or elsewhere. In discussing the effects of corrosion in tubes, it is laid down as an axiom that only solid drawn tubes should be used, on account of the liability of the welded tube to suffer injury by corrosion along the line of weld, a remark which is sadly significant after the late disaster to a boiler in H.M.S. *Terrible*, and the finding of the Court of Inquiry.

The next two parts deal in detail with the older forms of marine boilers, the Scotch boiler mainly, and the newer tubulous or water-tube boiler. Very full descriptions are given in the second section of the more important details in a cylindrical boiler, especially in regard to the tubes and to the stays, and the section concludes with a valuable table of weights, space occupied, &c.

The third section, on water-tube boilers, is the most complete and the most interesting, as was to be expected, the tubulous boiler now reigning almost supreme in the French navy, and its use in the French mercantile marine being fairly large. Three classes of such boilers are described in three separate chapters—the limited circulation class, type Belleville; the free circulation, types Niclausse, Babcock-Wilcox, &c.; and lastly the accelerated circulation, types Normand, Thornycroft, Yarrow, &c.

In each chapter practically every boiler of the class under description which has been actually tried in practice is illustrated and briefly explained, while very full detailed descriptions are given of one or two of the important forms, such as Belleville, Niclausse, Thornycroft, &c., with much valuable information as to their performances under steam.

The last chapter in Part iii. is devoted to an able summary of the advantages and disadvantages of the tubulous type of boiler, mainly, of course, from the point of view of the marine engineer; interesting contrasting figures of comparative weights, costs, &c., per square foot of grate render this chapter one of the most useful in the book. It is surprising how cheap these apparently complex water-tube boilers are, averaging 32*l.* per square foot of grate surface.

The four chapters in Part iv. are devoted to descriptions of boiler mountings and fittings, in particular to the automatic feed arrangements, so essential to many water-tube boilers; in these chapters the illustrations are very good.

The book undoubtedly is the most complete work on the subject issued in English up to the present, and is well up to date; it should prove a valuable work of reference, not only to the marine engineer, but to the intelligent layman who takes an interest in the efficiency of our navy. The water-tube boiler, much as Mr. Allen may dislike it, has come to stay; in our navy it will gradually displace the old Scotch boiler, and we should be surprised if it does not eventually make headway in the mercantile marine.

Any one reading the book and anxious to ascertain the trend of opinion amongst English marine engineers on this important question should consult the papers read a month or two ago before the Institution of Civil Engineers by Mr. Milton and Sir John Durston.

H. B.

OUR BOOK SHELF.

The Elements of Euclid. With Notes, &c., by I. Todhunter, D.Sc., F.R.S. New edition, revised and enlarged, by S. L. Loney, M.A. Pp. viii + 332, cxxxii. (London: Macmillan and Co., 1899.)

Essentials of Plane and Solid Geometry. By W. Wells, S.B. Pp. viii + 392. (London: Isbister and Co. Boston, D.C.: Heath and Co., 1899.)

WITHOUT altering the general character of the well-known text-book with which he has had to deal, Mr. Loney has succeeded very well in bringing it up to date. The appendix has been enlarged by the insertion of sections on poles and polars, harmonic ranges, inversion, coaxal circles, &c.; the number of exercises has been doubled, and, what is more important, the really valuable exercises have been starred and hints given for the solution of many of them. To teachers of the conservative school this new edition ought to prove very acceptable.

Mr. Wells' book is of quite another stamp. The author belongs to the progressive party, and makes no scruple of using hypothetical constructions or any abbreviations he finds convenient. In treating of parallels he uses Playfair's axiom, and the discussion of ratio and proportion is distinctly arithmetical. The exercises are numerous and often accompanied by figures; hints for solution are also given in many cases. Mr. Wells writes in a fresh and independent manner, and his book seems very likely to interest a student and develop any geometrical power he may have in the right way.

In another edition the author will, we trust, suppress the appendix (p. 386), which is almost entirely vitiated by an error of reasoning. Mr. Wells proposes, for instance, to prove that the circumference of a circle is less than the perimeter of any circumscribed polygon, and proceeds thus: "Of the perimeters of the circle and of its circumscribed polygons, there must be one perimeter such that all the others are of equal or greater length." He then proves that, given any circumscribed polygon, we can construct another one with less perimeter; and then infers the truth of the proposition. As a matter of fact, the statement quoted above is not justifiable; the perimeters of the polygons form a manifold, and this does not necessarily contain a least element; indeed, Mr. Wells shows that it does not. There may be a definite lower limit to the perimeter of a circumscribed polygon: even then, Mr. Wells brings forward no argument to show that this lower limit exists; still less that it is equal to the circumference of the circle. Strictly speaking, he brings the circumference of the circle into no relation of equality or inequality with any of the polygons: it just stands by itself at the end as at the beginning. It is as if one said: "We have a set of quantities x, 1·3, 1·33, 1·333, &c.; one of these must be at least equal to any of the rest. But this cannot be any of the decimals, because if we choose,

say, 1·3333, we can write down 1·33333, which is greater. *Therefore it must be x!*"

It is only fair to add that this unlucky paralogism seems to be a solitary blemish in an otherwise excellent book. G. B. M.

A Manual of Surgical Treatment. By W. Watson Cheyne, F.R.S., and F. F. Burghard, M.S., Surgeons to King's College Hospital, London. In six Parts. Part I. Pp. xiv + 285, with 66 illustrations in the text. (London and Bombay: Longmans, Green, and Co., 1899.)

SUCH a work as this has long been wanted by senior students, house-surgeons and general practitioners, who are often left in charge of capital operations performed by surgeons of repute without any precise directions as to the treatment to be adopted in cases of emergency. But the work undertakes much more than this, for it is evident that the authors will review the whole field of surgery in the light of our present pathological knowledge, showing the modern methods of treatment and explaining why they have replaced the older plans. The present part deals with the more general subjects of inflammation, gangrene, wounds, venereal disease, tuberculosis and tumours. It treats, therefore, of those parts of surgery which, perhaps more than all others, have been affected by antiseptic treatment. Mr. Watson Cheyne is so well known as one of the most distinguished pupils of Lord Lister that no better exponent of his methods could be found, and we are here presented with a clear account of the rationale of modern treatment. Thus, amongst many other more important things, we learn why poulticing is bad in the treatment of abscess, why a chronic abscess should be scraped, but an acute abscess should only have the matter let out and the loculi broken down. The facts and reasoning are excellent, but the pleasure of reading is too often marred by the form in which they are presented, as many of the sentences seem to be constructed upon a German model. The figures which illustrate the letterpress vary greatly in quality; some are excellent, others are sketchy, whilst others again are such mere outlines as to be almost unintelligible. Dr. Silk contributes an excellent article on the subject of anæsthetics, and there is a good index to this first part of the work.

Impressions of America. By T. C. Porter, M.A. (Oxon.), Fellow of the Chemical Society, of the Royal Astronomical Society, and of the Physical Society of London. Illustrated with diagrams and stereoscopic views. Pp. xviii + 242. (London: C. Arthur Pearson, Ltd., 1899.)

THE impressions were obtained during a pleasure trip to Niagara, the Yellowstone Park, San Francisco, the Yosemite, Utah and Colorado Springs. The author refrains from citing any of the scientific works dealing with the remarkable features of those interesting regions, but gives a graphic account of what he himself saw, and outlines a number of interesting hypotheses to account for some of the phenomena. Some of these are interesting because they show how a man of scientific habits of thought may from a hasty glance often reach conclusions very similar to those which the specialists who have studied the subject for years have demonstrated to be correct. We cannot accept Mr. Porter's ingenious hypothesis that the spiral ridges of the trunks of many trees in the Yellowstone Park are due to unequal heating by the sun and the uniform rotation of the earth, because he does not buttress it with the necessary explanation why trees in other places in the same latitude where the sun also shines unequally and the earth rotates uniformly do not also incline to a screwy form. But the little appendix on the Gulf Stream is a neat demonstration from the study of a single bottle-chart of the seasonal variation of the Gulf Stream and its attendant drift. Of course the deduction is not new; the fine charts of North Atlantic currents grouped for two-monthly intervals by the Meteorological Office bring it out perfectly, and the labours of American, British, and Scandinavian oceanographers, and of the Prince of Monaco, have done much to find the reasons for the observed variations. We might venture, however, to remind Mr. Porter that the course of the Gulf Stream shown on a single small scale map is as conventional and empirical a representation of oceanic circulation as the isotherms on a map of mean annual temperature are of the climates of the world. The generalisation in no way implies that the seasonal changes are unknown.

A new theory of geysers to fit the phenomena of the Yellowstone Park is also printed in the appendix in the form of a paper read to the Physical Society. It points out defects in Tyndall's well-known theory, and introduces a syphon-bend in the underground channel and the spheroidal state induced by the intense heat of the rocks as more probable explanations.

The great merit and the unique character of the book depend, however, not on the author's impressions or his theories, but on the incomparable series of photographs which he took. These are reproduced in the form of stereoscopic views, and a neat little lenticular stereoscope is supplied with the volume. The views shown in these illustrations are admirably selected and splendidly photographed. They are reproduced by the half-tone process as separate plates, and very well printed. As a diary of the observations of a man of science at leisure there is much of interest in the whole book, which has also the advantage of being brief. H. R. M.

Tables for Quantitative Metallurgical Analysis for Laboratory Use. By J. James Morgan, F.C.S., Member Soc. Chem. Industry, Member Cleveland Inst. Engineers. Tables xvi. (London: Charles Griffin and Co., Ltd., 1899.)

TABLES for qualitative analysis are to be found in every chemical laboratory, and are used by every analyst at one time or another. Any attempt to supply chemists with information on quantitative analysis drawn up in the same convenient form must therefore be welcome. The present collection of tables has been carefully prepared, and is well arranged. It includes the analyses of iron ores, steel, limestone, boiler incrustation, certain slags, gaseous fuels, water, coal, and a few of the common metals and alloys. Alternative methods are not given, but the tables will be found very useful in saving the time of an analyst engaged in the examination of materials with which he is not accustomed to deal in the ordinary course of his daily work.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Tides of the Gulf and River St. Lawrence and Bay of Fundy.

PERMIT me to invite your attention to the latest report of the engineer in charge of the survey of the tides and currents of the coast waters of Canada, Mr. W. Bell Dawson, a copy of which has been addressed to you.

This survey, commenced by the Government of Canada in 1894, is of great importance, not merely in the interest of hydrographical science, but of the large and increasing trade which finds its way along the gulf and river St. Lawrence, the greatest water-way from the North Atlantic into the northern part of the American continent, and which, like all

similar tide-ways, is affected by the complex action of the tides and consequent currents.

It is much to be regretted that the economy or parsimony of the Government has caused a suspension for the present of the special survey of the currents, and has restricted the work to tidal observations, which, though of great value to the shipping interests, can only be considered as preliminary in regard to the investigation of the currents themselves, which lead to so many losses of property and life, and tend to high rates of insurance, injurious to the shipowners and merchants of Canada, and through them to those of an empire as a whole.

The present report, in addition to what can be done with the insufficient grant allowed, in the matter of tide-gauges and tide-tables, has reference to the behaviour of the gigantic tides of the Bay of Fundy, when confined by the converging coasts at the head of the bay, and their relation to the smaller tides on the opposite side of the isthmus connecting Nova Scotia and New Brunswick at Bay Verte on the Gulf of St. Lawrence. These and the phenomena of the "bore" at the head of the Bay of Fundy are here for the first time described, illustrated by maps and sections, and tabulated, and will be found of the greatest interest by all who desire information as to the exceptional tides of this region.

J. W. DAWSON.

School Laboratory Plans.

As one who has had the privilege of seeing Mr. Dymond's excellent arrangement and outlay of money in his laboratory at Chelmsford, may I make a comment on his letter in your issue of July 13? I think the conditions of work in an average school laboratory show some points of difference from those in Mr. Dymond's laboratory. Of course qualitative analysis is now confined to quite senior boys, who can be persuaded not to treat the subject as if they were working from a cookery book; but though owning no allegiance to the Science and Art Department, I believe that drawers and lockers are valuable, not only in relieving the general stock of the laboratory (very heavy for descriptive and quantitative work) of some smaller apparatus in constant use, but also in conferring a feeling of ownership, which induces some care and respect in a boy for his belongings. With snap-locks answering to one master key, and the lockers of each class bearing a label of a distinctive colour, they may be at once opened by the assistant before a class, so that there need be no keys to lose and no depredations on neighbouring lockers. Mr. Dymond's objection to that most durable of woods—teak—or why it alone should be left in a dirty state, I do not understand. Admitting that in all but very elementary work some tuition in the way of lectures is necessary, a laboratory will generally possess a lecture room; and where this is a separate room, I grudge the space usually given to a demonstrator's table in the laboratory, because no large section of a practical class is ever doing the same experiment at the same time. Physics, again, is often involved in this question of arrangement in a school, since the two subjects may, I think, with little detriment and great economy often have a common lecture room. Considering the prodigal waste of space often seen in laboratories, and the number now being built by public bodies, some further views on this subject ought to be of value.

A. E. MUNBY.

Felsted School.

Duties of Provincial Professors.

THE article in your issue of July 13 upon "The Duties of Provincial Professors" will be welcomed by all professors in local university colleges. It insists none too strongly upon the disadvantageous position they occupy with regard to the opportunity for the prosecution of original research, and the unfortunate result of compelling our best students to complete their scientific education in Germany.

It is not sufficiently recognised that the reputation of a university is advanced more by the contributions to science and literature produced by its staff than by the mere number of its students. Unfortunately, the staff of assistants in the university colleges is often totally inadequate to the work required, and the knowledge that their energies will be dissipated in elementary teaching, and no time given for continuing original investigation, is deterring men of really high academic distinction from accepting such appointments. The government of a local college is largely directed by business men, and the methods which ensure commercial success are hardly those best calculated to further the interests of true education. Salvation lies apparently in the fact of Government inspection; the Government grant is only given when the education is of an advanced university type; and, judging from the tenor of the Treasury Minute, "University Colleges, Great Britain—Grant in Aid," the fullest recognition is given to those colleges which offer opportunities for advanced work and research and can show an adequate educational equipment.

"A PROFESSOR."

July 23.

IN the articles on "The Duties of Provincial Professors," it is stated: "In such cases students . . . may be called on to give evidence against their professors." This is almost incredible, but, to my great astonishment, I learnt quite lately that the only possible alteration in the statement consistent with truth would be the substitution of the words "have been" for "may be." The adoption of such a course must be fatal to good discipline in a college, and it leaves the members of the staff at the mercy of a few unruly and ignorant students whose disposition to learn may be small, though their capacity for agitation is great. From time to time students of this description will be found in every college. Apart altogether from these evils, there is another reason why the practice of allowing students to give evidence against a professor is decidedly objectionable; and that is, the lay members of the governing body of a provincial college are not likely to fully understand how incompetent the average pass student is to form an opinion as to the soundness of the teaching he receives.

In the interests, not merely of the provincial colleges, but of higher education throughout the country, it is desirable that professors should not, for any except very grave reasons, and then only after a perfectly fair trial, be forced to resign their offices.

P.

THE REDE LECTURE.[1]

THE WAVE THEORY OF LIGHT: ITS INFLUENCE ON MODERN PHYSICS.

OUR era is distinguished from preceding ages by wonderful utilisation of natural forces; man, that weak and defenceless being, has been enabled by his genius to acquire an extraordinary power, and to bend to his use those subtle yet dreadful agents whose very existence was unknown to our ancestors. This marvellous increase of his material power in modern times is due only to the patient and profound study of natural phenomena, to the exact knowledge of the laws that governed them, and to the skilful combining of their effects. But what is peculiarly instructive is the disproportion between the primitive phenomenon and the greatness of the effects which industry has drawn from it. Thus, those formidable engines, based on electricity or steam, grew neither from lightning nor the volcano; they had their birth from scarcely perceptible phenomena which would have remained for ever hidden from the vulgar eye, but that penetrating observers were able to recognise and appreciate. This humble origin of most of the great discoveries which are to-day a benefit to the

[1] Besides the interest presented by a glance on the progress and the influence of optical science, this lecture offers the conclusions of a careful study on Newton's treatise of optics. It will be seen that the thought of the great physicist has been singularly altered by a sort of legendary interpretation developed in the elementary treatises where the emission-theory is expounded. In order to make the theory of fits clearer, the commentators have imagined to materialise the luminous molecule under the form of a rotating arrow offering now its head, now its side. This mode of exposition has contributed to lead to the belief that the whole emission-theory was comprehended in this rather childish image.

Nowhere in his treatise does Newton give a mechanical illustration of the luminous molecule: he confines himself to the description of facts, and sums them up in an empirical statement without any hypothetical explanation. Moreover, he denies the opinion that he raises any theory, though he holds occasionally as very probable the intervention of the waves excited in the ether.

So that the general impression resulting from the reading of the treatise and above all of the "queries" in the 3rd Book, is the following: Newton, far from being the adversary of the Cartesian system, as he is commonly represented, looks, on the contrary, very favourably at the principles of this system. Struck by the resources which the undulatory hypothesis would offer for the explanation of the luminous phenomena, he would have adopted it, if the grave objection concerning the rectilinear propagation of light (only recently solved by Fresnel) had not prevented him.

whole human race, shows us plainly that the scientific spirit is at present the mainspring of the life of nations, and that it is in the onward march of pure science that we are to look for the secret of the growing power of the modern world. Whence a series of questions which demand more and more the attentions of all. How did this taste towards the study of natural philosophy, so dear to the ancient philosophers, abandoned for centuries, again revive and grow? What are the phases of its advance? How appeared the new notions which have so deeply modified our ideas on the mechanism of nature's forces? What paths, rich in discoveries, lead us gradually unawares to those admirable generalisations in accordance with the vast plan foreseen by the founders of modern physics? These are the questions which as a physicist I intend to inquire into before you. The subject is rather abstract, I might say severe. But no other has seemed more worthy of your attention during the *fête* which the University of Cambridge celebrates to-day in honour of the Lucasian Professorship Jubilee of Sir Geo. Gabriel Stokes, who in his fine career has laid a master-hand on the very problems which seemed to me the most conducive to the progress of natural philosophy. The subject is all the more fitted here, as in citing the names of those great minds to whom modern science is most indebted, we found amongst those who most honoured the University of Cambridge—its Professors and Fellows—Sir Isaac Newton, Thomas Young, George Green, Sir George Airy, Lord Kelvin, Clerk Maxwell, Lord Rayleigh, and the memory of that glory which links to-day back through the centuries would add lustre to the present ceremony.

Let us then, in a rapid glance of the scientific revival, point out the secret but mighty influence which has been the directing force of modern physics. I am inclined to attribute to the study of light, and to the attraction it has for the highest minds, one of the most effective causes of the return of ideas towards natural philosophy, and consider optics as having exercised on the advance of science an influence it would be difficult to exaggerate. This influence, already clear at the dawn of the experimental philosophy under Galileo, grew so rapidly that to-day it is easy to foresee a vast synthesis of natural forces founded on the principles of the wave theory of light. This influence is easy to understand if we reflect that light is the way by which knowledge of the exterior world reaches our intelligence. It is, in fact, to sight that we owe the quickest and most perfect notions of the objects around us: our other senses, hearing, feeling, also bring their share of learning, but sight alone affords us abundant means of simultaneous information such as no other sense can. It is, therefore, not surprising that light, this lasting link between us and the outward world, should intervene with the varied sources of its inner constitution to render more precise the observation of natural phenomena. Thus each discovery concerning new properties of light has had an immediate effect on the other branches of human knowledge, and has indeed determined the birth of new sciences by affording new means of investigation of unexpected power and delicacy.

Optics are really a modern science. The ancient philosophers had no idea of the complexity of what is vulgarly called light; they confounded in the same name what is proper to man, and what is exterior. They had, however, perceived one of the characteristic properties of the link, which exists between the source of light and the eye, which receives the impression, "Light moves in a straight line." Common experience had revealed this axiom through the observation of the shining trains that the sun throws across the skies, piercing misty clouds, or penetrating into some dark space. Hence arises two empirical notions—the definition of the ray of light, and that of the straight line. The one became the basis of optics, the other that of geometry.

Very little remains to us of the ancient books upon optics. Yet we are aware that they knew the reflection of the luminous rays on polished surfaces, and the geometrical explanation of the images formed by mirrors.

We must wait many centuries until the scientific revival for a new progress in optics (but then a very considerable one) opens the new era; it is the invention of the telescope.

The new era begins with Galileo, Boyle and Descartes, the founders of experimental philosophy. All devote their life to meditations on light, colours, and forces. Galileo lays the base of mechanics and with the refracting telescope that of astro-physics. Boyle improves experimentation. As to Descartes, he embraces with his penetrating mind the whole of natural philosophy; he throws away the occult causes admitted by the scholastics, and proclaims as a principle that all phenomena are governed by the laws of mechanics. In his system of the universe, light plays a prominent part[1]: it is produced by the waves excited in the subtle matter which, according to his view, pervades space. This subtle matter (which represents what we call to-day the ether) is considered by him as formed of particles in immediate contact; it constitutes thus at the same time the vehicle of the forces existing between the material bodies which are plunged in it. We recognise the famous "vortices of Descartes," sometimes admired, sometimes baffled during the last centuries, but to which skilful contemporaneous physicists have rendered the importance they deserve.

Whatever may be the opinions granted to the exactness of the deductions of this great philosopher, we must be struck by the boldness with which he proclaims the connection of the great cosmical problems, and foretells the solutions which actual generations did not yet entirely accept but drew insensibly to.

In Descartes' view the mechanism of light and that of gravitation are inseparable; the seat of corresponding phenomena is this subtle matter which pervades the universe, and their propagation is performed by waves around the acting centres.

This conception of the nature of light shocked the opinions in vogue; it raised strong opposition. Since the oldest times it was the habit to imagine the luminous ray as the trajectory of rapid projectiles thrown by the radiant source. Their shock on the nerves of the eye produce vision; their resistance or changes of speed, reflection or refraction. The Cartesian theory had, however, some seductive aspects which brought defenders. The waves excited on the surface of still water offer so clear an image of a propagated motion around a disturbing centre! On the other hand, do not the sonorous impressions reach our ear by waves? Our mind feels yet a real satisfaction in thinking that our most sharp and delicate organs are both impressed by a mechanism of the same nature.

Yet a serious difference arose. Sound does not necessarily travel in straight lines as light does. It travels round any object opposed to it, and will follow the most circuitous routes with scarcely any loss of strength. Physicists were thus divided into two camps. In one the partisans of emission, in the other those of the wave theory, each system boasting itself superior, and indeed each being so in certain respects. Other phenomena had to be examined in order to decide between them.

The chance of discovery brought to view several phenomena which ought to have decided in favour of wave theory, as was proved a century later; but the simplest truth does not prevail without long endeavour.

A strange compromise was effected between the two systems, helped on by a name great among the greatest, and for a century the theory of emission triumphed.

The tale is a strange one. In 1661 a young scholar,

[1] *Le Monde de M. Descartes, ou le Traité de la Lumière* (Paris, 1664).

full of eagerness and penetration, enters Trinity College, Cambridge; his name is Isaac Newton. He has already in his village read Kepler's "Optics." Almost immediately, and while following Barrow's lectures upon optics, he studies the geometry of Descartes with passionate care; with his savings he buys a prism that he might examine the properties of colour and meditate deeply on the causes of gravitation. Eight years later his masters think him worthy to succeed Barrow in the Lucasian Professorship, and in his turn he also teaches optics. The pupil soon becomes greater than his teacher, and he gives out this great result: White light which seemed the type of pure light is not homogeneous; it consists of rays of different refrangibility, and he demonstrates it by the celebrated experiment of the solar spectrum, in which a ray of white light is decomposed into a series of coloured rays like a rainbow; each shade of the colour is simple, for the prism does not decompose the shade. This is the origin of the spectral analysis. This analysis of white light brought Newton to explain the colours of the thin plates which are, for instance, observed in soap-bubbles. The fundamental experiment, that of Newton's rings, is one of the most instructive in optics, while the laws that govern it are of admirable simplicity.

The theory was expounded in a discourse addressed to the Royal Society with the title, "A New Hypothesis concerning Light and Colour."

This discourse called forth from Hooke, a sharp complaint. Hooke also had already examined the colour of thin plates, and endeavoured to explain them in the wave system. He had the merit, which Newton himself readily granted, to substitute for the progressive wave of Descartes a vibrating one—a new and extremely important notion. He had even noticed the part of the two reflecting surfaces of the thin plate, and the mutual action of the reflected waves. Consequently Hooke should have been the very forerunner of the modern theory if he had had, as Newton, the clear intelligence of the simple rays. But his vague reasoning to explain the colours takes away all demonstrative value from his theory.

Newton is very affected by this complaint of priority, and combats the arguments of his adversary by remarking that the wave theory is inadmissible because it does not explain the existence of the luminous ray and of the shadows. He denies the opinion that he has raised a theory; he certifies that he does not admit either the wave hypothesis or the emission, but he says "He shall sometimes, to avoid circumlocution and to represent it conveniently, speak of it as if he assumed it and propounded it to be believed." And, really, in the Proposition XII. (second book of his Optics),[1] which constitutes what was since called the theory of fits, Newton remains absolutely on the ground of facts. He says simply, the phenomena of thin plates prove that the luminous ray is put alternatively in a certain state or fit of easy reflexion and of easy transmission. He adds, however, that if an explanation of these alternative states is required they can be attributed to the vibrations excited by the shock of the corpuscles, and propagated under the form of a wave in ether.[2]

After all, notwithstanding his desire to remain on the firm ground of facts, Newton cannot help trying a rational explanation. He has too carefully read the writings of Descartes not to be heartily, as Huygens, a partisan of the universal mechanism and not to wish secretly to find in the pure undulations the explanation of the beautiful phenomena he has reduced to such simple laws. But his third book on optics more especially proves his Cartesian aspirations, and, above all, his perplexity. His famous "Queries" expose so forcibly his argument in favour of the wave theory of light that Thos. Young will later cite them as proof of the final conversion of Newton to the wave theory. Newton would certainly have yielded to this secret inclination had the inflexible logic of his mind allowed him to do so; but when after enumerating the arguments the wave theory of light offers in explanation of the intimate nature of light, when he arrived at the last "queries" he stops, as if seized by a sudden remorse, and throws it away. And the sole argument is that he does not see the possibility of explaining the rectilinear transmission of light.[1] Viewed from this standpoint the third book of *Optiks* is no longer only an

[1] Prop. XII.—Every Ray of Light in its passage through any refracting Surface is put into a certain transient constitution or state, which in the progress of the Ray returns at equal Intervals, and disposes the Ray at every return to be easily transmitted through the next refracting Surface, and between the returns to be easily reflected by it. (Sir Isaac Newton, "*Opticks*: or a *Treatise* of the Reflections, Refractions, Inflexions and Colours of *Light*." London, 1718. Second edition, with additions. P. 293.

[2] *Loc. cit.*, p. 299.

[1] First, here is an extract from the "Queries" which prove the leaning of Newton's views towards the undulatory theory and the Cartesian ideas.

"Query 12.—Do not the Rays of light in falling upon the bottom of the eye excite Vibrations in the *Tunica Retina*? Which Vibrations, being propagated along the Solid Fibres of the optick nerves into the brain, cause the Sense of seeing. . ."

"Query 13.—Do not several sorts of Rays make Vibrations of several bignesses, which, according to their bignesses, excite sensations of several colours, much after the manner that the vibrations of the air, according to their several bignesses, excite sensation of several sounds? And particularly do not the most refrangible rays excite the shortest vibrations for making a sensation of deep violet, the least refrangible the largest for making a sensation of deep red, &c.? . . ."

"Query 18.— . . . Is not the heat of the warm room convey'd through *the vacuum* by the vibrations of a much subtiler medium than air, which, after the air was drawn out remained in the *vacuum*? [ether] and is not this medium the same with that medium by which light is refracted and reflected, and by whose vibrations light communicates heat to bodies, and is put into fits of easy reflection and easy transmission? . . . And is not this medium exceedingly more rare and subtile than the air, and exceedingly more elastic and active? and doth it not readily pervade all bodies? and is it not (by its elastick force) expanded through all the heavens?"

Newton, afterwards, considers the possible connection of this medium (ether) with the gravitation and the transmission of the sensations and motion in living creatures (queries 19 to 24).

The dissymetrical properties of the two rays propagated in the Iceland spar, draw equally his attention (query 25 to 26).

Here appears this sudden and unexpected going back, this sort of remorse from having too kindly expounded the resources of the Cartesian theory, based on the *plenum*; he makes an apology as follows:

"Query 27.—Are not all hypotheses erroneous which have hitherto been invented for explaining the phenomena of light, by new modifications of the rays? . . ."

"Query 28.—Are not all hypotheses erroneous in which light is supposed to consist in pression or motion, propagated through a fluid medium? . . . and if it (light) consisted in pression or motion, propagated either in an instant or in time, it would bend into shadow. For pression or motion cannot be propagated in a fluid in right lines beyond an obstacle, which stops part of the motion, but will bend and spread every way into the quiescent medium which lies beyond the obstacle. . . . For a bell or a canon may be heard beyond a hill which intercept the light of sounding body, and sounds are propagated as readily through crooked pipes as through straight ones. But light is never known to follow crooked passages nor to bend into the shadow. . . ."

Stopping before this objection Newton is forced to come back to the corpuscular theory.

"Query 29.—Are not the rays of light very small bodies emitted from shining substances? . . ."

"Query 30.—Are not gross bodies and light convertible into one another . . .? The changing of bodies into light and light into bodies, is very conformable to the course of nature, which seems delighted with transmutations. . . ."

Logic urges him to go on with the old hypothesis of the *vacuum* and *atoms*, and even to invoke the authority of the Greek and Phœnician philosophers in this matter (query 28, p. 343), therefore it is not surprising to see his perplexity expressed by the following words:—

"Query 31, and the last.—Have not the small particles of bodies certain powers, virtues, or forces, by which they act at a distance not only upon the rays of light for reflecting, refracting and inflecting them, but also upon one another for producing a great part of the phenomena of nature? . . ."

But he perceives that he is going rather far, and compromising himself, therefore his secret tendency, developed in the foremost queries, reappear a little while:—

". . . How these attractions may be performed I do not here consider. What I call attraction may be perform'd by impulse, or by some other means unknown to me . . ."

Many other curious remarks could be made on the state of mind of the great physicist, geometer and philosopher, which is artlessly revealed in those "queries." The preceding short extracts are sufficient, I believe, to justify the conclusion which I get from the study of the 3rd Book, namely, that Newton had not at all on the mechanism of light the definite ideas which have been attributed to him as founder of the emission-theory. Really, he is hesitating between the two opposite systems, perceiving clearly their insufficiency; and in this discussion he is endeavouring to go away as little as possible from the facts. That is the reason for which he has stated no dogmatic theory. It would be, therefore, unjust to make Newton responsible for every consequence which the emission partisans have sheltered under his authority.

impartial discussion of opposite systems; it appears as the painting of the suffering of a mighty genius, worried by doubt, now led away by the seductive suggestions of his imagination, now recalled by the imperious requirements of logic. It is a drama: the everlasting struggle between love and duty; and duty won.

Such, I take it, is the inner genesis of the theory of fits—a strange mingling of two opposite systems. It was much admired, presented, as it was, by the great mathematician, who had the glory of submitting the motions of all celestial bodies to the one law of universal gravitation.

To-day this theory is abandoned; it is condemned by the *experimentum crucis* of Arago, realised by Fizeau and Foucault. One ought, however, to acknowledge that it has constituted a real progress by the precise and new notions which it contains. The ray of light, considered up till then, was simply the trajectory of a particle in rectilinear motion; the ray of light, such as Newton described it, possesses a regular periodic structure, and the period or interval of fits, characterises the colour of the ray. This is an important result. It only requires a more suitable interpretation to transform the luminous ray into a vibratory wave; but we had to wait a century, and Dr. Thomas Young, in 1801, had the honour of discovering it.

Resuming the study of thin plates, Thomas Young shows that everything is explained with extreme simplicity, if it be supposed that the homogeneous luminous ray is analogous to the sonorous wave produced by a musical sound; that the vibrations of ether ought to compose—that is to say, to interfere—according to the expression that he proposes as to their mutual actions.

Although Young had taken the clever precaution of supporting his views by the authority of Newton,[1] the hypothesis found no favour; his principle of interference led to this singular result that light added to light could, in certain cases, produce darkness, a paradoxical result contradicted by daily experience. The only verification that Young brought forward was the existence of dark rings in Newton's experiment, darkness due, according to him, to the interference of waves reflected on the two faces of the plate. But as the Newtonian theory interpreted the fact in a different manner, the proof remained doubtful; an *experimentum crucis* was wanting. Young did not have the good success to obtain it.

The theory of waves relapsed then once more into the obscurity of controversy, and the terrible argument of the rectilinear propagation was raised afresh against it. The most skilled geometers of the period—Laplace, Biot, Poisson—naturally leaned to the Newtonian opinion; Laplace in particular, the celebrated author of the "Mecanique Celeste," had even taken the offensive. He was going to attack the theory of waves in its most strongly fortified entrenchments, which had been raised by the illustrious Huygens.

Huygens, indeed, in his "Traité de la Lumière," had resolved a problem before which the theory of emission had remained mute; that is to say, the explanation of the double refraction of Iceland spar: the wave theory (on the contrary) reduced to the simplest geometrical construction the path of the two rays, ordinary and extraordinary; experiment confirmed the results in every point. Laplace succeeded in his turn (with the help of hypotheses of the constitution of luminous particles) to explain the path of these strange rays. The victory of the theory of particles then appeared complete; a new phenomenon arrived also appropriately to render it striking.

Malus discovered that a common ray of light reflected under a certain angle acquired unsymmetrical properties similar to those rays from a crystal of Iceland spar. He explained this phenomenon by an orientation of the luminous molecule, and, consequently, named this light *polarised light.* This was a new success for emission.

The triumph was not of long duration. In 1816 a young engineer, scarcely out of the École Polytechnique, Augustin Fresnel, confided to Arago his doubts on the theory then in favour, and pointed out to him the experiments which tended to overthrow it.

Supporting himself on the ideas of Huygens, he attacked the formidable question of rays and shadows, and had resolved it; all the phenomena of diffraction were reduced to an analytical problem, and observations verified calculation marvellously. He had, without knowing it, rediscovered Young's reasonings as well as the principle of interference; but more fortunate than he, he brought the *experimentum crucis*—the two-mirror experiment; there, two rays, issuing from the same source, free from any disturbance, produced when they met, sometimes light, sometimes darkness. The illustrious Young was the first to applaud the success of his young rival, and showed him a kindness which never changed.

Thus, thanks to the use of two-mirror experiment, the theory of Dr. Young (that is to say, the complete analogy of the luminous ray and the sound wave) is firmly established.

Moreover, Fresnel's theory of diffraction shows the cause of their dissimilarity; light is propagated in straight lines because the luminous waves are extremely small. On the contrary, sound is diffused because the lengths of the sonorous waves are relatively very great.

Thus vanished the terrible objection which had so much tormented the mind of great Newton.

But there remained still to explain another essential difference between the luminous wave and the sonorous wave; the latter undergoes no polarisation. Why is the luminous wave polarised?

The answer to this question appeared so difficult that Young declared he would renounce seeking it. Fresnel worked more than five years to discover it; the answer is as simple as unexpected. The sound wave cannot be polarised because the vibrations are longitudinal; light, on the other hand, can be polarised because the vibrations are transverse, that is to say, perpendicular to the luminous ray.

Henceforth the nature of light is completely established, all the phenomena presented as objections to the undulatory theory are explained with marvellous facility, even down to the smallest details.

I would fain have traced by what an admirable suite of experiment and reasoning Fresnel arrived at this discovery, one of the most important of modern science: but time presses.

It has sufficed me to explain how very great the difficulties were which he had to overcome in order to establish it.

I hasten to point out its consequences.

You saw, at starting, the purely physiological reasons which make the study of light the necessary centre of information gathered by human intelligence. You judge now, by the march of this long development of optical theories, what preoccupations it has always caused to powerful minds interested in natural forces. Indeed, all the phenomena which pass before our eyes involve a transmission to a distance of force or movement; let the distance be infinitely great, as in celestial space, or infinitely small, as in molecular intervals, the mystery is the same. But light is the agent which brings us the movement of luminous bodies; to fathom the mechanism of this transmission is to fathom that of all others, and Descartes had the admirable intuition of this when he comprehended all these problems in a single mechanical conception: here is the secret bond which has always attracted the physicists and geometers towards the study

[1] The Bakerian Lecture, "On the Theory of Light and Colours." By Thomas Young. *Phil. Trans.* of the R.S. for the year 1802.

of light. Looked at from this point of view, the history of optics acquires a considerable philosophical importance; it becomes the history of the successive progress of our knowledge on the means that nature employs to transmit movement and force to a distance.

The first idea which came to the mind of man (in the savage state) to exercise his force beyond his reach is the throwing of a stone, of an arrow or of some projectile; this is the germ of the theory of emission. This theory corresponds to a philosophical system which assumes an empty space in which the projectile moves freely. At a more advanced degree of culture, man having become a physicist, has had the more delicate idea of the transmission of movement by waves, suggested at first by the study of waves, afterwards by that of sound.

This second way supposes, on the other hand, that space is a plenum; there is no longer here transport of matter; particles oscillate in the direction of propagation, and it is by compression or rarefaction of a continuous elastic medium that movement and force are transmitted. Such has been the origin of the theory of luminous waves; under this form it could only represent a part of the phenomena; it was therefore insufficient.

But geometers and physicists before Fresnel did not know of any other undulatory mechanism in a continuous medium.

The great discovery of Fresnel has been to reveal a third mode of transmission quite as natural as the preceding one, but which offers an incomparable richness of resources. These are the waves of transverse vibrations excited in an incompressible continuous medium, those which explain all the properties of light.

In this undulatory mode the displacement of particles brings into play an elasticity of a special kind; this is the relative slipping of strata concentric to the disturbance which transmits the movement and the effort. The character of these waves is to impose on the medium no variation of density as in the system of Descartes. The richness of resource mentioned above depends upon the fact that the form of the transverse vibration remains indeterminate, and thus confers on waves an infinite variety of different properties.

The rectilinear, circular and elliptical forms characterise precisely the polarisations, so unexpected, which Fresnel discovered, and by the aid of which he has so admirably explained the beautiful phenomena of Arago produced by crystallised plates.

The possible existence of waves which are propagated without change of density, has profoundly modified the mathematical theory of elasticity. Geometers found again in their equations, waves having transverse vibrations which were unknown to them; they learnt besides, from Fresnel, the most general constitution of elastic media, of which they had not dreamt.

It is in his admirable memoir on double refraction that this great physicist set forth the idea that in crystals the elasticity of the ether ought to vary with the direction, an unexpected condition and one of extreme importance, which has transformed the fundamental bases of molecular mechanics; the works of Cauchy and Green are the striking proofs of it. From this principle Fresnel concluded the most general form of the surface of the luminous wave in crystals, and found (as a particular case) the sphere and ellipsoid that Huygens had assigned to the Iceland spar crystal. This new discovery excited universal admiration among physicists and geometers; when Arago came to expound it before the Académie des Sciences, Laplace, who had been such a long time hostile, declared himself convinced. Two years later Fresnel, unanimously elected a member of the Academy, was elected with the same unanimity foreign member of the Royal Society of London; Young himself transmitted to him the announcement of this distinction, with personal testimony of his sincere admiration.

The definite foundation of the undulatory theory imposes the necessity of admitting the existence of an elastic medium to transmit the luminous movement. But does not all transmission to a distance of movement or of force imply the same condition? To Faraday is due the honour of having, like a true disciple of Descartes and Leibnitz, proclaimed this principle, and of having resolutely attributed to reactions of surrounding media the apparent action at a distance of electrical and magnetic systems. Faraday was recompensed for his boldness by the discovery of induction.

And since induction acts even across a space void of ponderable matter, one is forced to admit that the active medium is precisely that which transmits the luminous waves, the ether.

The transmission of a movement by an elastic medium cannot be instantaneous; if it is truly luminous ether that is the transmitting medium, ought not the induction to be propagated with the velocity of luminous waves?

The verification was difficult. Von Helmholtz, who tried the direct measurement of this velocity, found, as Galileo formerly, for the velocity of light a value practically infinite.

But the attention of physicists was attracted by a singular numerical coincidence. The relation between the unity of electrostatic quantity to the electro-magnetic unit is represented by a number precisely equal to the velocity of light.

The illustrious Clerk Maxwell, following the ideas of Faraday, did not hesitate to see in the relationship the indirect measure of the velocity of induction, and by a series of remarkable deductions he built up this celebrated electro-magnetic theory of light, which identifies in one mechanism three groups of phenomena completely distinct in appearance, light, electricity, and magnetism.

But the abstract theories of natural phenomena are nothing without the control of experiment.

The theory of Maxwell was submitted to proof, and the success surpassed all expectation. The results are too recent and too well known, especially here, for it to be necessary to insist upon them.

A young German physicist, Henry Herz, prematurely lost to science, starting from the beautiful analysis of oscillatory discharges of Von Helmholtz and Lord Kelvin, so perfectly produced electric and electro-magnetic waves, that these waves possess all the properties of luminous waves; the only distinguishing peculiarity is that their vibrations are less rapid than those of light.

It follows that one can reproduce with electric discharges the most delicate experiments of modern optics —reflection, refraction, diffraction, rectilinear, circular, elliptic polarisation, &c. But I must stop, gentlemen. I feel that I have assumed too weighty a task in endeavouring to enumerate the whole wealth which waves of transverse vibrations have to-day placed in our hands.

I said at the beginning that optics appeared to me to be the directing science in modern physics.

If any doubt can have arisen in your minds, I trust this impression has been effaced to give place to a sentiment of surprise and admiration in seeing all that the study of light has brought of new ideas on the mechanism of the forces of nature.

It has insensibly restored the Cartesian conception of a single medium refilling space, the seat of electrical, magnetic and luminous phenomena; it allows us to foresee that this medium is the depositary of the energy spread throughout the material world, the necessary vehicle of every force, the origin even of universal gravitation.

Such is the work accomplished by optics: it is perhaps the greatest thing of the century!

The study of the properties of waves, viewed in every aspect, is therefore, at the present moment, the most fertile study.

It is that which has been followed in the double capacity of geometer and physicist by Sir George Stokes, to whom we are about to pay so touching and deserved a homage. All his beautiful researches, both in hydrodynamics as well as in theoretical and practical optics, relate precisely to those transformations which various media impose on waves which traverse them.

In the many phenomena which he has discovered or analysed, movements of fluids, diffraction, interference, fluorescence, Röntgen rays, the dominant idea which I pointed out to you is always visible; it is that which makes the harmonious unity of the scientific life of Sir George Stokes.

The University of Cambridge may be proud of the Lucasian Chair of Mathematical Physics, because from Sir Isaac Newton up to Sir George Stokes it has contributed a glorious part towards the progress of Natural Philosophy! A. CORNU.

NOTES.

WE are glad to be able to publish this week a translation of the Rede Lecture delivered at Cambridge by Prof. Alfred Cornu, professor of experimental physics in the École polytechnique, Paris, and a Foreign Member of the Royal Society, on the occasion of the recent celebration of the jubilee of Sir George Stokes as Lucasian professor of mathematical physics. Prof. Cornu delivered the lecture in French, and we are indebted to him for the translation of his brilliant discourse, which immediately precedes this Note.

AN interesting gathering took place at the Star and Garter Hotel, Richmond, on Thursday last, when a number of friends joined with the members of the Physiological Society in giving a congratulatory dinner to Sir John Burdon-Sanderson, Bart., F.R.S., and Prof. Michael Foster, K.C.B., Sec.R.S., in honour of Her Majesty's recent recognition of the great services they have rendered to science. The chair was taken by Prof. Schäfer, F.R.S., and the friends who assembled to support him in doing honour to the distinguished guests numbered considerably over a hundred. The principal speeches of the evening were made by the chairman, by Sir John Burdon-Sanderson, and by Prof. Michael Foster, all of whom were able to give interesting reminiscences of the early days of physiology in England, and of the great difficulties which used to be thrown in the way of those who wished to study the subject. Owing to the exigencies of the various examinations now in progress, many physiologists were unable to be present in the earlier part of the evening, but the great interest taken in the proceedings was shown by the long journeys undertaken by several in order that they might take part at the dinner.

THE special number of the *Atti*, containing the report of the anniversary meeting of the Reale Accademia dei Lincei, announces the annual awards of prizes. The Royal prize for astronomy for 1896 remains unawarded. The Royal prize for philology and languages is divided equally between Prof. Pio Rajna, for his critical edition of Dante's "De Vulgari Eloquentia," and Prof. Claudio Giacomino, for his studies on the Basque language. The prize for history and geography is unawarded, and the same is true of a prize offered for 1898 for perfecting the theory of motion of a rigid body. The Ministerial prize of 3400 lire for history for 1898 is divided, a prize of 1700 lire being awarded to Prof. Gaetano Salvemini, and smaller awards being made to Profs. Alberto Pirro, Niccolò Rodolico, and Michele Rosi. Of the Ministerial prize of 3400 lire for mathematics for 1898, a prize of 2000 lire is awarded to Prof. Ettore Bortolotti, and awards of 700 lire each are made to Profs. Federico Amodeo and Francesco Palatini. The adjudicators state that the works of Prof. Pirondini would have gained an award had not some of them received recognition on a previous occasion. The adjudicators of the Ministerial prize for philosophical and social sciences for 1897 award 500 lire each to Profs. Albino Nagy, Luigi Ambrosi, and Tarozzi. The Mantellini prize is unawarded. Of the Santoro prize for electro-technics one half is awarded to Signor R. Arnò, for his share in the joint invention with the late Prof. G. Ferraris of a new transformer. The Santoro prize for chemistry as applied to agriculture is unawarded, and from the Carpi prize for mathematical physics for 1897–8 a sum of 500 lire is awarded to Signor C. Canovetti, for his papers on the direction of aerostats and on the resistance of the air.

IN connection with the preparation of argon, a good deal of attention has been paid to the absorption of nitrogen by metals. Prof. Ramsay, it will be remembered, used magnesium. Later, lithium was proposed by Ouvrard, and a mixture of lime and magnesium by Maquenne. The subject has recently been systematically investigated by Dr. Hempel, who finds that a mixture of calcium magnesium and sodium is very much more effective than the agents just named. The mixture is obtained by using 1 gramme of finely divided magnesium, 5 grammes coarsely powdered lime, and 0·25 grammes sodium. In a comparative time experiment the rates of absorption of nitrogen by magnesium, lithium, lime-magnesium, and lime-magnesium-sodium were in the ratio 1, 5, 8 and 20.

TO commemorate the completion of the twenty-five years of active work as a teacher of physiology of Prof. Purser, of Trinity College, Dublin, a movement is on foot among the professor's former pupils to raise funds for the bestowment annually of a "Purser Medal" to the candidate who, in the half M.B. examination, shows the highest proficiency in physiology and histology. Subscriptions, which are not to exceed a guinea, should be forwarded to the honorary treasurer, Dr. W. J. Houghton, 30 Lower Fitzwilliam Street, Dublin.

DR. MAXWELL T. MASTERS, F.R.S., has been made an officer of the Order of Leopold by the King of the Belgians.

THE Neill Prize for 1895–98 has been awarded to Prof. J. Cossar Ewart, F.R.S., by the Royal Society, Edinburgh, for his experiments and investigations bearing on the theory of heredity.

THE King of Sweden has conferred upon Mr. E. P. Martin, past-President of the Iron and Steel Institute, a Knight-commandership of the Royal Order of Wasa, and upon Mr. Bennett H. Brough, present Secretary of the Institute, a Knighthood of the same Order.

A DEPUTATION from the Iron and Steel Institute, consisting of Sir W. C. Roberts-Austen, K.C.B., F.R.S., President, Sir Lowthian Bell, Bart., F.R.S., Mr. E. P. Martin, past-Presidents, and Mr. Bennett H. Brough, Secretary, waited upon the Queen last week for the purpose of presenting to Her Majesty an illuminated address and the Bessemer Gold Medal, in commemoration of the great progress made in the iron and steel trade during the Queen's reign.

THE Meteorological Council have appointed Captain Campbell M. Hepworth, R.N.R., to fill the post of Marine Superintendent in succession to the late Mr. Baillie. Captain Hepworth has been an observer for the Meteorological Office for twenty-three years, and almost all of his logs have been classed "excellent."

A MEETING of the Aeronautical Society will be held at the Society of Arts to-morrow (July 28) at eight p.m.

THE summer meeting of the Institution of Mechanical Engineers was opened at Plymouth on Tuesday. In connection

with the meeting the Freedom of the Borough of Devonport has been presented to the president, Sir W. H. White, K.C.B., F.R.S.

THE thirty-sixth annual conference of the British Pharmaceutical Society of Great Britain was opened on Tuesday at Plymouth, the president, Mr. J. C. C. Payne, Belfast, being in the chair. The executive committee reported that the total membership was 1303. A number of papers on technical subjects were read and discussed.

THE Japanese Government have, it is stated, decided to make vaccination compulsory in Japan. All children must be vaccinated before the age of ten months. The first re-vaccination is to take place at six, and the second at twelve years of age.

MR. C. J. LYONS, writing in the U.S. *Weather Review*, from Honolulu, points out that most prominent volcanic outbursts on Hawaii have occurred at times of minimum sun-spots; so that, if the connection is real, a great lava flow may be expected at some time between now and 1901. Whether the years of maximum sun-spots are coincident with the years of no eruption does not appear to have been examined by Mr. Lyons.

A REUTER telegram of July 21 from New York states that the crater on the peak of Mauna Loa, Hawaii, burst into violent eruption on the 4th inst. Lava flowed down in three streams, one going towards Hilo and the two others in the direction of the sea, threatening the coffee plantations and the sugar lands.

A SPECIMEN of the egg of the Great Auk was sold by auction at Stevens's Rooms last week, and, although slightly cracked, realised the sum of 300 guineas, which equals the amount paid for the specimen sold at the same place in 1894. The egg just sold was figured in the *Memoirs* of the Société Zoologique de France in 1888, and, with additional notes on its history, it appeared in the *Bulletin* of the Société in 1891.

THE *Astrophysical Journal* for June states that a conference of astronomers and astrophysicists will, on the invitation of Prof. Hale, be held at the Yerkes Observatory, Williams Bay, Wis., U.S.A., from September 6 to 8 next. In its plan and scope the conference will be similar to those held in 1897 and 1898 at Williams Bay and Cambridge, Mass., respectively. The committee charged with perfecting a plan for the organisation of a permanent society of astronomers and astrophysicists, to have charge of future conferences, will present its report.

ACCORDING to the *Athenaeum*, Dr. Sven Hedin has set out upon his new journey of exploration in Central Asia, and expects to be absent for about two and a half years, principally in East Turkestan and the northern part of Tibet. The Russian Government has accorded him free passage on the Russian railway and free transmission of his very extensive equipment. For his Asiatic travel, as in his earlier journeys, a guard of Cossacks is to be placed at his disposal upon his application where necessary.

THE annual meeting of the British Medical Association will be held at Portsmouth next week. The proceedings will commence on Tuesday, August 1, when Dr. J. Ward Cousins, Southsea, will deliver the presidential address in the town-hall. On Wednesday and following days the sections will meet in the mornings and afternoons. On Wednesday evening a *soirée*, invitations to which will be issued by the president, will be held in the town-hall, and on Thursday the annual dinner of the Association will be held in the same building, to be followed by a reception organised by the ladies' committee. On Friday night Alderman T. Scott Foster will give a ball at the town-hall. The meeting will be brought to a conclusion on Saturday evening, August 5.

WE learn from *Science* that Clark University, Worcester, Massachusetts, has just celebrated its decennial in a manner worthy of a university devoted to the advancement of science. The following lectures were delivered in connection with the celebration: Prof. Ludwig Boltzmann, of the University of Vienna, on the "Principles and Fundamental Equations of Mechanics"; Prof. Picard, of the University of Paris, on "Differential Equations," and on "Analytical Functions"; Prof. Angelo Mosso, of the University of Turin, on "The Relation between Muscular Exercise and the Development of Mental Power," and on "Bodily Disturbances accompanying the Emotions"; Prof. Santiago Ramon y Cajal, of the University of Madrid, on the "Structure of the Visual Cortex of the Human Brain," and Prof. August Forel, of Zürich, on "Hypnotism," and on "Arts."

AN International Congress of Physics, to be held during the Paris Exposition next year, is being organised by a Committee of the Société française de Physique. The congress will commence on August 6, 1900, and will last a week. Though a number of special congresses are being arranged, it is thought that a congress having for its object the discussion of fundamental questions of physical science will be of interest to all physicists. Among the subjects to be dealt with in reports and discussions are the definition of certain units, such as pressure, scale of hardness, quantity of heat, photometric values, constants of saccharimetry, spectrum scale, and electrical units not yet defined; bibliography of physics; and national laboratories. There will also be visits to exhibits of scientific interest in the Exposition, to laboratories and to manufactories; and conferences on some new subjects, to be announced later, will be arranged. The president of the organising committee is Prof. Cornu; vice-president, M. Cailletet; and secretaries, M. C. E. Guillaume (au Pavillon de Breteuil, Sèvres, Seine-et-Oise) and M. Lucien Poincaré (105 *bis* boulevard Raspail, Paris), the former being the secretary for foreign members, and the latter for France.

FROM the *Bulletin de la Société d'Encouragement* we learn that an International Congress of Applied Mechanics has been organised for 1900 in connection with the Universal Exhibition. A draft programme has already been drawn up, and the subjects for discussion include mechanical laboratories, mechanical applications of electricity, high-speed steam engines, the mechanics of motor cars and implements. The Congress will open on July 19, 1900, and will last a week. Full particulars are obtainable from the Secretary of the Commission, 44 rue de Rennes, Paris.

THE Berlin correspondent of the *Lancet* gives a few particulars concerning the institution for the study of tropical diseases, shortly to be erected in Hamburg by the Government. It was the wish of Prof. Koch and the medical faculty that the institution should find a home in Berlin, in connection with, and as a department of, the Institution for Infectious Diseases. The Government, however, was of opinion that Hamburg would be preferable because a large number of patients coming from tropical climates and suffering from the specific diseases of the tropics are received into the Hamburg hospitals. In this way the new institution will have ample material for study, whilst if the institution were established in Berlin the patients would have to be conveyed from Hamburg and other seaports to the metropolis, a proceeding which would eventually be prejudicial to them. It is neither decided yet when the institution will be opened nor who will be appointed director. Probably one of the Colonial medical officers will be placed in charge.

ACCORDING to the *Journal of Applied Microscopy*, it is proposed to hold a bryological meeting at Columbus, Ohio, during the session of the American Association for the Advancement of Science at that place. It is intended to present a series of papers, illustrated by specimens, photographs, microscopical slides, books and pamphlets, and to show the work done by leading workers on the subject. In addition to these will be shown collections of specimens, macroscopic and microscopic, illustrating the monographic work of living American students, and foreign students who have worked on North American mosses will be asked to co-operate.

THE weather was very warm and dry last week, and the thermometer reached a higher point than on any previous occasion this summer. At Greenwich there were five consecutive days on which the shade temperature exceeded 80°, and on Wednesday and Friday the thermometer exceeded 88°. In some of the London suburbs the air temperature was highest on Friday, the 21st, the thermometer in Stevenson's screen touching 90° in the south of the metropolis. The highest temperature in the sun's rays at Greenwich occurred on Wednesday, when the thermometer registered 158°, which is higher than any reading during the previous three years. A sharp thunderstorm passed over the metropolis on Sunday morning, and the accompanying rainfall was generally heavy. At Greenwich the fall of rain exceeded three-quarters of an inch, at Westminster an inch was measured, while at Brixton the rain amounted to half an inch, and in some localities it was even less. A cooler air has spread over the British Islands during the last few days, and the general type of weather is favourable to occasional showers, so that at length the recent drought may reasonably be considered at an end.

THE United States *Monthly Weather Review* for March contains an interesting historical account of the meteorological services in Russia, and especially of the Central Physical Observatory, by Prof. Cleveland Abbe, from which we extract the following notes. This institution is dependent upon the Academy of Sciences, which was established by decree of Peter the Great, dated January 22, 1718, and its first public session was held on January 7, 1726. Prof. A. T. Kupffer, born in 1798, was the first director and organiser of the meteorological system in Russia; his first volume of "Observations météorologiques et magnétiques" was published in 1837. Subsequent issues attracted the attention of the Emperor, who ordered that the work should appear as an annual volume under the title "Annuaire magnétique et météorologique." These volumes appeared up to that for 1846, which was published in 1849. In the meantime (April 13, 1849) the Emperor established the Central Physical Observatory, and the *Annuaire* thereafter appeared under the title "Annales de l'Observatoire Physique Central," and these were published up to the time of Kupffer's death in 1865. Thereupon Prof. Kämtz (born 1801) was called from Dorpat; but he died in 1867. His successor was Prof. H. Wild, born at Zürich in 1833. He held the directorship until July 1895, when he resigned on account of health; but he still remains an honorary member of the Academy of Sciences of St. Petersburg. During his administration a great impetus was given to all meteorological and magnetical work, and the volumes of the *Annales* 1865-9 were edited by him. With the volume for 1870 a new series, under the title "Annalen des Physikalischen Observatoriums," was begun, and under his auspices the new observatory at Pavlovsk was established for the purpose of scientific investigation. The appointment of General Rykatcheff (who began working with Prof. Kämtz in 1866) as director of the meteorological service in 1895 marks a general change in the spirit of administration of affairs in Russia, where the so-called Russian element is at present predominant. The memoirs bearing on the work of the observatory are now published in Russian by the Physical Section of the Academy of Sciences; while the observations properly so-called, consisting entirely of numerical tables, are published in separate volumes under the former title of "Annales de l'Observatoire."

AN ingenious machine for printing in colours, invented by Mr. Ivan Orloff, chief engineer and manager of the Russian Government printing works at St. Petersburg, has just been set up in London, and a company has been formed to develop the use of the machine for supplying coloured illustrations for periodicals and books. In colour printing by the ordinary method the successive colours are applied one at a time as the preceding one becomes dry. By means of the Orloff machine the whole of the colours required in a picture are printed at a single turn of the cylinder. If a picture has to be printed in, say, four colours, four separate blocks are arranged around the curved surface of the cylinder. As each block passes a particular point, the roller carrying the colour required by the block is made to fall upon it by a system of cams. Each block thus receives the coloured ink intended for it in the course of a revolution of the cylinder. All the printing surfaces, as soon as they are inked, transfer their designs to a composition roller which they pass, and this in turn transfers the combined coloured design to a final surface or *forme* carried on the same cylinder as the separate blocks, and from this *forme* the fully-coloured picture is imprinted upon paper at one impression. The fundamental idea of the machine is thus to print the separate colours in succession upon a common surface, and then to use the single surface as the *forme* in the final printing. These operations go on continuously. The cylinder completes one revolution in one-twentieth of a minute, within which time every colour surface has been inked and re-inked with its proper colour, and has delivered the result to the *forme* to be impressed upon paper. The results are very effective, and the "register" is perfect, no matter how many colours are used. The machine appears to mark a distinct development of methods of printing in colours.

FROM the *Standard* of July 22 we learn that the Botanical Garden of the Vienna University can now boast of possessing specimens of a plant not to be found in any similar institution in the world, or, indeed, anywhere else in Europe or America. When the Austrian Expedition to Southern Arabia, under Prof. Dr. David Heinrich Müller, was out there last winter, Prof. Dr. Oskar Simony, son of the well-known geographer, succeeded in obtaining some incense bushes, notwithstanding that the Arabs keep the places where they grow a secret from Europeans. He brought them to Vienna alive, and they are now in full leaf.

IN the *Mathematical Gazette* for June, published under the auspices of the Mathematical Association, Prof. F. Morley communicates a note on the sphero-conic, in which he gives a simplified proof of the bifocal property. Mr. S. A. Saunders calls attention to the paradoxical questions arising from the notion of motion *at* an instant, a conception which like pressure *at* a point involves a peculiar use of the word "at." Mr. R. F. Davis contributes a paper on "Porismatic Equations"; and there is the usual collection of problems and solutions and reviews of text-books.

ONLY one article in the new part of the *Quarterly Review* is of scientific interest; it deals with the important subject of climate and colonisation. The writer of the article, after surveying a selection of the literature of the subject, and commenting on the efforts that have been or are being made towards a better understanding of tropical diseases, says: "Europeans who settle in tropical countries must not expect to remain unchanged from generation to generation. Even when there is no intercrossing, although the main features may persist for a long while, the new surroundings gradually give their own

impress. In all countries where Europeans have settled, we find they have altered in temperament, ideas, and bodily features. The change is slow at first, because fresh blood constantly streams in from the mother country and perpetuates the original characters; but as the Colony grows older the immigration falls off, and the new settlers diverge further and further from the original type. We have no reason to dread this evolution; it is the outcome of adaptation; and when we consider the splendid physical characteristics of many of the native races which inhabit tropical regions, we may fairly conclude that such adaptation will lead to the development of new types no whit inferior to the old. When we further consider that man, modifying the environment and substituting his selection for that of nature, has been able to produce and to develop endless varieties of domestic animals which would never have come into existence under natural conditions, and would soon deteriorate or perish when out of their artificial surroundings, we may certainly believe that he can, by taking thought, escape many of those detrimental influences which irresistibly modify all other organic beings."

"THE Geology of the Coolgardie Goldfield" forms the subject of the third *Bulletin* of the Geological Survey of Western Australia, and it is written by Mr. Torrington Blatchford, Assistant Government Geologist. This goldfield was discovered in 1892, and in the course of six years over two thousand tons of ore have been crushed, yielding gold at the rate of 1 oz. 3 dwt. per ton. This has been derived mainly from quartz reefs and partly from "lode formations." The amount of gold obtained from the rich alluvial deposits has not been estimated. The district of Coolgardie consists of a mass of granite on the west, succeeded by a belt of hornblendic and talcose schists, the whole being intersected by igneous dykes. Recent superficial deposits cover a large portion of the field, and at the base of these there is in places a thin stratum of "cement," an auriferous conglomerate that has not yet proved of much economic value. Gold is found in pyrites in the altered schists bordering the acid dykes, and the material is traversed by numerous small quartz leaders forming "stockworks." Though much gold has been won from this source, the lodes are small and irregular. The quartz reefs occur principally in the schists, and they dip from 60° to 80° to the east. The water-supply of the region is a source of trouble and expense. With a rainfall of only seven inches no great supply can be expected, except by storing. Shallow wells yield limited supplies up to 4000 gallons per diem at a depth of 200 feet, but a good deal of the underground water is saline. Deep boring has been unsuccessful, and supplies have in some cases to be brought from a distance. An excellent coloured geological map, on a scale of an inch to forty chains, has been prepared by Mr. Blatchford and Mr. E. L. Allhusen. This is an index to a larger map which is published separately.

IN the *Philosophical Magazine* for July the Rev. O. Fisher deals with the residual effect of a former glacial epoch upon underground temperatures. The object of the paper is to examine whether traces of the effects left by a former glacial period upon underground temperatures are sufficient in amount to enable estimates to be made, from observations in deep wells and mines, of the lapse of time since the ice disappeared from the land. The author investigates the character of the traces which a former glaciation might be expected to leave behind, the principal one being a reduction of the gradient. From observations of the temperature of a well at Wheeling, U.S.A., combined with a certain assumption, the author estimates the time of the glacial period at 34,013 years. On the whole, however, he considers that the question as to whether there is any prospect of estimating the date of the glacial epoch from underground temperatures must be answered in the negative; nevertheless, the different gradients observed in different localities may possibly be attributable in a measure to glaciation.

IN No. 8 of the series of *Frammenti concernanti la geofisica* (Rome) Dr. Folgheraiter gives an interesting account of the singular magnetic effects produced by lightning on a house at Torre Nuova, which was struck on April 8 last. The observations led the author to conclude (1) that the lightning produced a large number of singular points and zones in the masonry, it being inadmissible that the individual stones should have been so highly magnetised before construction of the walls; (2) that while doubts have hitherto existed as to the possible formation of singular points in tufa, this question has now been answered in the affirmative; (3) the alternation in the polarities of the singular points and zones, even on the same piece of tufa, is noteworthy, but no connection has yet been established between these alternations and the mode of propagation of the electricity; (4) it is now amply proved that lightning produces marked magnetisation independently of the inductive action of terrestrial magnetism.

WE have received a paper by the Rev. F. S. Chevalier, S.J., published by the Zi-ka-Wei Observatory, on the navigation of the Upper Yang-tze. The author's knowledge of the river is chiefly derived from personal observation made during a voyage as far up as Ping-shan-hsien during the winter of 1897–98. He takes a much more hopeful view of the navigability of the Upper Yang-tze than did Lieut. Dawson, whose survey is reported on in the *China Sea Directory*. The three chief obstacles, in the form of rapids, are discussed in detail, and suggestions are made with the view of making their navigation practicable. M. Chevalier has in preparation a chart of the river from I-chang to his highest point, on a scale of 1/25,000.

THE debatable question of the diffraction of Röntgen rays forms the subject of some recent experiments described by Prof. H. Haga and Dr. C. H. Wind in the *Proceedings* of the Royal Academy of Sciences of Amsterdam. In such experiments it is better, in order to obtain greater intensity, to use narrow slits than to make the distances great. As the time of exposure varied from 29 to 200 hours, the apparatus had to be mounted on a heavy freestone block supported on the central pillar of the Physical Laboratory of the University of Groningen, where the experiments were made. The diffraction slit was 3 cm. high and 14 microns at the upper end, gradually narrowing to a width of a few microns. A careful examination shows a kind of broadening out of the image corresponding to the narrowing of the slit, and this it is considered can only be attributed to diffraction of the Röntgen rays. The authors give estimates of the wave-lengths of the rays lying between 0,12 and 2,7 Ångström units, but consider that they cannot succeed in making measurements instead of estimations of the wave-length until Röntgen tubes have been produced remaining in working order as long as those used, and giving out rays of much greater energy.

THOSE responsible for the "Guide to the Museum of Eton College," seem remarkably fond of displaying an acquaintance with technical terms. Why, for instance, in giving a list of the birds of Berkshire, was it necessary to encumber it with the subheadings "Neornithes," and "Carinatæ," seeing that all existing birds come under the former category, and all those of Europe under the latter? If the number of names were reduced, and the language somewhat simplified throughout, the *Guide* would be admirable for its purpose. The museum appears to be well arranged; and it is satisfactory to note that the authorities recognise the importance of making the local collection the most prominent feature.

THE report of the Magnetical and Meteorological Observations made at the Government Observatory, Bombay, for the year 1897 has just been issued, with an appendix.

MESSRS. ISENTHAL, POTZLER, AND CO., of Mortimer Street, have sent us a supplementary list of new radiographic instruments made by them. Attention is drawn to several pieces of apparatus of recent construction.

WE have received the prospectus of the "One and All" Flower-show, an exhibition of horticultural photographs, to be held at the Crystal Palace on August 14–19, under the auspices of the "Agricultural and Horticultural Association, Limited."

IN the number of the *Biologisches Centralblatt* for July 1, Dr. R. Keller finishes his review of recent advances in vegetable physiology and botany; and Dr. G. Lindner his account of the germs of Protozoa found in rain water.

THE *Cambridge University Reporter* for June 22 contains the annual report of the Botanic Garden Syndicate for the year 1898. Several interesting and important additions have been made to the Botanic Garden during the year.

IN the numbers of the *Agricultural Gazette of New South Wales* for May and June is a continuation of M. A. O'Callaghan's series of papers on dairy bacteriology. It contains a report, with illustrations, of the bacteriological condition of a number of butters produced in the Colony.

THE Trinidad *Bulletin of Miscellaneous Information* (Botanical Department, No. 19) contains a preliminary report by Mr. G. Massee on the cacao pod disease, which is rife in the Colony. Mr. Massee ascribes it to a fungus belonging to the Peronosporeæ.

IN the *Irish Naturalist* for July is a synopsis of the Irish Characeæ, by Prof. T. Johnson; a paper on some algæ from the Antrim coast, by H. Hanna; and one on some freshwater mites from Co. Dublin, by D. Freeman.

THE *Transactions* of the Manchester Microscopical Society contains several papers which show a record of good work in microscopy:—The genitalia and radulæ of the British Hyalinia, by W. Moss; *Peripatus Leuckarti*, by F. Paulden; Scale insects, by A. T. Gillanders; *Myriothela Phrygia*, a tubularian hydroid, by W. Blackburn; and others.

WE have received a copy of Dr. Gunnar Andersson's "Studies of the Quaternary Flora of Finland" (*Bulletin de la Commission Géol. de Finlande, Helsingfors*, 1898). The work is accompanied by four excellent plates of fossil seeds, and it contains descriptions and sections of the peaty deposits from which they have been obtained.

THE current issue of the *Reliquary and Illustrated Archaeologist* contains many interesting contributions, among which may be mentioned "Antiquities of Bolsterstone and Neighbourhood," "The Instrument of the Rosary," "Two Midlothian Souterrains," "The Grinlow Barrow, Buxton," and "Notes on Archæology and Kindred Subjects." As is usual in this magazine the articles are well illustrated.

MR. ARTHUR S. EAKLE describes some andesites from the Fiji Islands (*Proc. Amer. Acad. Arts and Sciences*, May 1899). Augite-andesite seems to be the predominating rock of the islands, and it varies from types having a small amount of augite with a large amount of felspar, and with biotite as an accessory, to those in which augite is the dominant constituent, thus showing a gradation into basalt.

VOL. II., part 6, of the serial form of C. E. Groves's translation of Fresenius' "Quantitative Analysis" has now been brought out by Messrs. J. and A. Churchill; the University Correspondence College has issued its Matriculation Directory dated June 1899, in which will be found articles on the special subjects for January and June 1900; a new edition of "The Arithmetic of Electrical Measurements," by W. R. P. Hobbs, has been issued by Murby. The work has been revised and in part re-written.

THE additions to the Zoological Society's Gardens during the past week include an Anubis Baboon (*Cynocephalus anubis*, ♀) from Accra, presented by Mr. G. B. Haddon Smith; a Feline Dourocouli (*Nyctipithecus vociferans*) from Brazil, presented by Mrs. Arthur Harter; a Ring-tailed Lemur (*Lemur catta*) from Madagascar, presented by Mrs. T. Butt Miller; a Spotted Ichneumon (*Herpestes auro-punctatus*) from Malacca, presented by Mr. Geo. F. Aress; a Levaillant's Cynictis (*Cynictis penicillata*), two Bristly Ground Squirrels (*Xerus setosus*) from South Africa, presented by Mr. J. E. Matcham; a Common Duiker (*Cephalophus grimmi*, ♂) from South Africa, presented by Captain G. C. Denton; two Cormorants (*Phalacrocorax carbo*) from Scotland, presented by Mr. P. L. Pemberton; a Ground Hornbill (*Bucorvus abyssinicus*) from West Africa, presented by Mr. Geo. Hirst; two Blood-rumped Parrakeets (*Psephotus haematonotus*) from Australia, presented by Mrs. A. Chambers; a Golden Eagle (*Aquila chrysaëtus*) from Scotland, presented by Mr. H. C. Ross; three Adorned Terrapins (*Chrysemys ornata*) from Mexico, presented by Mr. C. J. Rickards; a Burchell's Zebra (*Equus burchelli*, ♀) from South Africa, two Hairy Armadillos (*Dasypus viliosus*) from La Plata, a Lion Marmoset (*Midas rosalia*) from South-east Brazil, a Blue-fronted Amazon (*Chrysotis aestiva*) from South America, deposited; a Chattering Lory (*Lorius garruius*) from Moluccas, purchased; two Collared Fruit Bats (*Cynonycteris collaris*), a Burrhel Wild Sheep (*Ovis burrhel*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

ASTRONOMICAL OCCURRENCES IN AUGUST:—

August 2. 11h. 25m. Minimum of Algol (β Persei).
11. Maximum of the August meteoric shower of Perseids.
14. 8h. 25m. to 9h. 37m. Occultation of the star D.M. – 22°, 3989 (mag. 6) by the moon.
14. 9h. 4m. Transit (immersion) of Jupiter's Sat. III.
15. Illuminated portion of the disc of Venus 0·989, of Mars 0·949.
18. 10h. 28m. to 11h. 34m. Occultation of *f* Sagittarii (mag. 5·1) by the moon.
22. 9h. 21m. to 10h. 15m. Occultation of 16 Piscium (mag. 5·6) by the moon.
22. 15h. 1m. to 16h. 8m. Occultation of 19 Piscium (mag. 5·2) by the moon.
23. Outer minor axis of Saturn's outer ring = 17″·94.
25. 9h. 57m. Minimum of Algol (β Persei).
26. 12h. 5m. to 13h. 5m. Occultation of τ^2 Arietis (mag. 5·2) by the moon.
26. 12h. 55m. to 13h. 51m. Occultation of 65 Arietis (mag. 5·6) by the moon.
27. 16h. 20m. to 17h. 19m. Occultation of v^1 Tauri (mag. 4·6) by the moon.
27. 16h. 49m. to 18h. 9m. Occultation of v^2 Taur (mag. 5·5) by the moon.
29. 16h. 9m. to 17h. 25m. Occultation of η Geminorum (mag. variable) by the moon.
30. 14h. 59m. to 15h. 58m. Occultation of ζ Geminorum (mag. variable) by the moon.

TEMPEL'S COMET 1899 *c* (1873 II.).

Ephemeris for 12h. Paris Mean Time.

1899.		R.A. h. m. s.		Decl. ° ′ ″		Br.
July 27	...	20 47 55·4	...	–21 56 9	...	3·698
28	...	49 6·7	...	22 29 17		
29	...	50 18·0	...	23 2 17		
30	...	51 29·2	...	23 35 4		
31	...	52 40·5	...	24 7 36	...	3·673
Aug. 1	...	53 51·8	...	24 39 49		
2	...	55 3·2	...	25 11 40		
3	...	20 56 14·6	...	–25 43 7		

The comet is now as bright as it is expected to become according to computation, and moreover is rapidly moving southwards, so that it will soon be beyond the reach of observers in these latitudes. During the week it passes from a position near the 6th mag. star 17 Capricorni to the vicinity of the 4th mag. red star A Capricorni.

STELLAR AND NEBULAR SPECTRA WITH CONCAVE GRATING.—In the earlier part of 1898 Messrs. Poor and Mitchell described the results of their attempts to photograph stellar spectra with a Rowland concave grating (*Astro-Physical Journal*, 8, p. 157). The grating used was a small one, having a ruled surface of only 1 × 2 inches with 15.000 lines to the inch, the radius of curvature being about 1 metre. Later a special grating was made with a ruled surface 2 × 5⅜ inches, having 7219 lines to the inch. The radius of curvature of this was also 1 metre. The instrument was mounted on the 9·3-inch Hasting's refractor as guiding telescope, and the results obtained were very promising, although the observatory is on the *sixth* floor of the Physical Laboratory at Baltimore. In November 1898, however, by the kindness of Prof. Hale, it became possible for Mr. Mitchell to mount the grating on the 12-inch Brashear refractor of the Yerkes Observatory (*Astro-Physical Journal*, x. pp. 29-39, 1899). It will be remembered that the grating is used "*direct*," the concave surface bringing the diffracted beam from the star to focus on the plate, and that a considerable advantage obtains in that the spectra obtained are *normal*. The grating was so oriented that the lines were parallel to the equator, so that irregularities in the driving-clock should have no effect on the definition. The astigmatism alone not being sufficient to give the spectrum sufficient width, this was effected by allowing the star to trail in right ascension. Photographs of the spectra of a large number of stars have been thus obtained, with exposures varying from 5 to 60 minutes. These are given in a table in the article. Of special interest is the fact that these photographs show the ultra-violet region remarkably well, as is to be understood when it is remembered that the light has to traverse neither lenses, prism trains nor slit. The photograph of Sirius showed about 75 lines between $H\beta$ and $H\gamma$, and in the ultra-violet 21 lines of the series due to hydrogen were measured.

In February two very interesting photographs of the spectrum of the Orion nebula were obtained with exposures of about 200 minutes. Just as with an objective prism, these spectra consist of a series of images of the nebula, the measures of corresponding regions of which give the wave-lengths of the various lines they represent.

With the grating used, the length of the photographic region in the first order was about 1¼ inches, using Seed's gilt edge plates. In the second order the distance from $H\beta$ to $H\gamma$ was 0·6 inch, and from $H\beta$ in the first order to $H\beta$ in the second was 2·8 inches. The photographic plate used, 1 × 5 inches, thus included both spectra, and their duplicate measurement afforded a definite control over the wave-lengths determined.

Attention is directed to the fact that the spectra being *normal*, absolute measurements of wave-length, and therefore of motion in line of sight, may be determined when larger instruments of this kind are available. A grating with ruled surface 10 × 15 inches would probably be fully equal in performance to any spectroscopes in present use.

THE REASON FOR THE HISSING OF THE ELECTRIC ARC.[1]

II.

AND now we come to the most important of all the changes that take place when the arc begins to hiss, viz. the alteration in the shape of the *positive* carbon.

During the course of his 1889 experiments, Luggin (*Wien Sitzungsberichte*, 1889, vol. xcviii. p. 1192) observed that the arc hissed when the crater filled the whole of the end of the positive carbon. He was thus the first to call attention to the fact that there was a direct connection between hissing and the relation between the area of the crater and the cross-section of the tip of the positive carbon. My own observations in 1893 led to a conclusion somewhat similar to Luggin's, but yet differing in an important particular. It seemed to me that, with hissing arcs, the crater always *more* than covered the end of the positive carbon—that it overflowed, as it were, along the side. How far this is true will be seen from an examination of Figs. 4, 5, 6 and 7, which show the shaping of the carbons under various conditions with silent and hissing arcs. These figures have all been made from tracings of the images of actual normal arcs, burning between carbons of various sizes, and they were carefully chosen with special reference to the shaping of the positive carbons. For, with normal arcs, the shape of the end of a positive carbon, even taken quite apart from that of the negative carbon and of the vaporous arc itself, is capable of revealing almost the whole of the conditions under which the arc was burning when it was formed. It is possible, for instance, with a normal arc, to tell, from a mere drawing of the outline of the positive carbon and of its crater, whether the arc with which it was formed had been open or enclosed, short or long, silent or hissing, burning with a large or with a small current for the size of the carbon.

Take, for example, Fig. 4 (see p. 285, July 20), and note the difference in the shape of the positive carbon with a current of 3·5 amperes, as in (*a*), and with one of 34 amperes, as in (*b*). In the first case the tip of the positive carbon is rounded, so that the crater lies in its smallest cross-section; in the second, the tip would be practically cylindrical for some distance, but that the

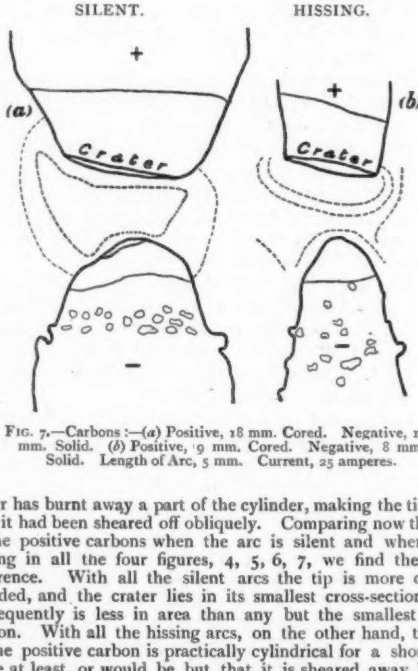

FIG. 7.—Carbons:—(*a*) Positive, 18 mm. Cored. Negative, 15 mm. Solid. (*b*) Positive, 9 mm. Cored. Negative, 8 mm. Solid. Length of Arc, 5 mm. Current, 25 amperes.

crater has burnt away a part of the cylinder, making the tip look as if it had been sheared off obliquely. Comparing now the tips of the positive carbons when the arc is silent and when it is hissing in all the four figures, 4, 5, 6, 7, we find the same difference. With all the silent arcs the tip is more or less rounded, and the crater lies in its smallest cross-section, and consequently is less in area than any but the smallest cross-section. With all the hissing arcs, on the other hand, the tip of the positive carbon is practically cylindrical for a short distance at least, or would be but that it is sheared away by the crater; consequently the area of the crater is *greater* than the smallest cross-section of the tip, or, indeed, than the cross-section of the tip for some little distance along its length.

We have now arrived at the real, the *crucial*, distinction between a silent and a hissing arc. When the crater occupies the *end* of the positive carbon only, the arc is *silent*; when it not only covers the end, but also extends up the *side*, the arc *hisses*. Hence, the arc must be at the *hissing point* when the smallest increase in the area of the crater will make it begin to cover the *side* of the positive carbon, and this can only be when the tip of that carbon has very nearly the same cross-section for some little distance from its end—in other words, when its sides are nearly vertical.

I shall now proceed to show that the extension of the crater up the side of the positive carbon is not the *effect* but the *cause* of hissing; that, in fact, *hissing is produced by the crater be-*

[1] Based on a paper read before the Institution of Electrical Engineers by Mrs. W. E. Ayrton. (Continued from page 286.)

coming too large to occupy the end only of the positive carbon, and therefore extending up its side.

Simple as is this explanation of a very complicated series of phenomena, it is the true one; but before proceeding to demonstrate its truth it will be interesting to see how the laws for the largest silent currents with normal arcs, which have already been obtained from the electrical measurements on pp. 283, 284, may be deduced on the above hypothesis from Figs. 6 and 7.

In Fig. 6 (p. 285) we have a series of four normal arcs of the same length burning between solid carbons of the same diameter; but in (*a*) the current is 6 amperes, in (*b*) 12, in (*c*) 20, and in (*d*) 30 amperes. The bluntness of the tip of the positive carbon may be measured by the obtuseness of the angle ABC. In (*a*) the tip is very blunt, and the area of the crater is certainly less than any but its smallest cross-section; therefore the arc is certainly silent. In (*b*) the tip is less blunt, but the arc is still evidently silent; in (*c*) the angle ABC is much more nearly a right angle, and it is plain that a very small increase in the area of the crater would cause it to burn up the side of the tip; therefore the arc is near the hissing point. In (*d*) the angle ABC is practically a right angle, the tip of the positive carbon is cylindrical, and the crater has evidently burnt partly up its side. Thus with a normal arc, keeping the length of the arc constant and gradually increasing the current, must bring us to a hissing point.

This brings me to the reason for the great importance of distinguishing between arcs that are normal and those that are not. For although, with normal arcs of any given length, hissing only starts when the current is *greater* than it can be with any silent arc of the same length, with a *non*-normal arc of 2 mm. I have been able to produce hissing with a current of 11 amperes, and to have a silent arc burning with a current of 28 amperes, the same carbons being used in each case.

The reason of this is obvious. When the arc is normal, the carbon ends and crater have a perfectly definite size and shape corresponding with each current and length of arc, and changes in these are made slowly, so as to allow time for the carbons to assume their proper form in each case. If, however, the current be *suddenly* much increased, when, say, the carbons have previously been very pointed, then the area of the crater may increase so rapidly that it will extend up the side of the carbon and cause hissing, even although the carbons would have shaped themselves so that there would have been room for the crater to remain at the end of the carbon if the change had been made more gradually.

Suppose, for instance, the end of the positive carbon were filed to a long fine point, then a very small current would make a crater large enough to extend up the side of the point, and produce a hissing arc. If, on the contrary, the end were filed flat, so as to have as large a cross-section as possible, quite a considerable current could flow silently even with a short arc, for in that case it would require the current to be very great for the crater to be large enough to fill up the whole of the end of the positive carbon.

Next, I have shown elsewhere (*The Electrician*, 1895, vol. xxxiv. p. 614) that, with a constant current, the end of the positive carbon becomes rounder and blunter, and occupies a larger portion of the entire cross-section of the carbon rod, the more the carbons are separated. Hence the longer the arc the greater must be the area of the crater, and consequently the greater must be the current, before the crater extends up the side of the positive carbon. Consequently, the longer the arc the greater is the largest silent current.

Thirdly, it follows that when the current and the length of the arc have been increased to such an extent that the round, blunt tip of the positive carbon occupies the whole cross-section of the carbon rod itself, no further increase in the size of the crater is possible without a part of it extending up the side of the carbon. Hence the largest silent current for a positive carbon of a particular diameter cannot exceed a particular value, however long the arc may be made. And lastly, similar reasoning, used in conjunction with Fig. 7, tells us that the thicker the positive carbon the greater must be the largest current that can flow silently with a particular length of arc, which was one of the results deduced from the curves in Figs. 2 and 3.

Thus the fact that hissing occurs when the crater covers more than the end surface of the positive carbon and extends up its side, combined with our knowledge of the way in which the positive carbon shapes itself in practice, is sufficient to enable us to deduce *all* the laws given on pp. 283, 284 which govern the largest current that will flow silently with the *normal* arc under given conditions.

We come now to the question, why should the arc hiss when the crater burns up the side of the positive carbon—what happens then that has not happened previously?

In pondering over this question, the possibility occurred to me that as long as the crater occupied only the *end* surface of the positive carbon it might be protected from direct contact with the air by the carbon vapour surrounding it, but that, when the crater overlapped the side, the air could penetrate to it immediately, thus causing a part at least of its surface to *burn* instead of volatilising. Many circumstances at once seemed to combine to show that this was the true explanation. The dancing circles I observed, and Mr. Trotter's stroboscopic images, how were they caused but by draughts getting into the arc? Then the humming noise, which sounds like the wind blowing through a crack, was not this probably caused by the air rushing through a slight breach in the crater, already getting near to the critical size? This air pouring in faster and faster as the breach widened would cause the arc to rotate faster and faster, sometimes in one direction, sometimes in another, according as the draught was blown from one side or the other. Then, finally, the air would actually reach the crater, burn in contact with it, and the P.D. would fall and the arc would hiss.

In the open arc, whether silent or hissing, the outer envelope of the vaporous portion is always bright green. With the hissing arc the light issuing from the *crater* is also bright green or greenish blue. What so likely as that the two green lights should have a common origin, viz. the combination of carbon with air? For the outer green light is seen just at the junction of the carbons and carbon vapour with the air, and the inner one only appears when air can get direct to the crater.

Again, why does the arc always hiss when it is first struck? Is it not because a certain amount of air must always cling to both carbons when they are cold, so that when the crater is first made its surface must combine with this air?

The cloud that draws in round the crater when hissing begins would be a dulness caused by the air cooling the part of the crater with which it first came into contact, the bright spots being at the part where the crater and air were actually burning together. In fact everything seemed to point to the direct contact of crater and air as being the cause of hissing and its attendant phenomena.

One easy and obvious method of testing this theory immediately presented itself. If air were the cause, exclude the air, and there would be no sudden diminution of the P.D. between the carbons, however great a current might be used. Accordingly I tried maintaining arcs of different lengths in an enclosed vessel, and increasing the current up to some 40 amperes. *No* sudden diminution of the P.D. could be observed with any of the currents or lengths of arc employed, although when the same carbons were used to produce *open* arcs, the sudden diminution of 10 volts in the P.D. between the carbons occurred with a current as low as 14 amperes for a 1 mm. arc.

It was, of course, impossible, in these experiments, to avail myself of an ordinary enclosed arc lamp, such as is used for street lighting, since a current of only some 5 or 8 amperes is all that is used with such a lamp, whereas to test my theory it was necessary to employ currents up to 40 amperes. Accordingly I constructed little electric furnaces of different kinds, one of which is shown in Fig. 8.

Some curves connecting the P.D. between the carbons with the current when the arc was completely enclosed in the crucible (Fig. 8) are given in Fig. 9. The carbons were similar to those used with the open arc experiments (Fig. 1, p. 282), being solid, the positive 11 mm. and the negative 9 mm. in diameter. As this crucible—the first one made—had no window, the length of the arc could not be kept quite constant, but the distance by which the carbons were separated was noted at the beginning of the experiment, and they were then allowed to burn away, without being moved, till the end, when the distance the positive carbon had to be moved in order to bring it tightly against the negative was noted. Measured in this way, the length of the arc was 1·5 mm. at the beginning and 2 mm. at the end of the experiment. The current was started at 6 amperes, and gradually increased to 39 amperes; then as gradually diminished to 6 amperes again, increased to 36 amperes, and diminished to 5 amperes, when the arc was extinguished. The

P.D. between the carbons for a given current seems to have increased as the length of time during which the arc had been burning increased; this was undoubtedly partly due to the lengthening of the arc, but was probably also partly due to the whole of the air in the pot having been gradually burnt up or driven out through the slag wool and the asbestos ring by the pressure of the carbon vapour.

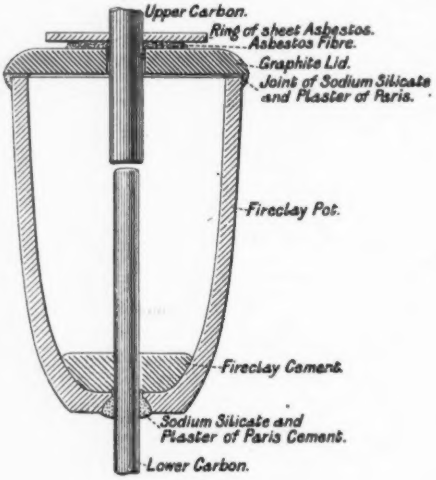

FIG. 8.

Many other sets of curves were obtained, but all with the same result, viz. that when once the crucible had been freed from air, no sudden diminution in the P.D. could be observed on increasing the current far beyond the value at which this diminution occurred on lifting up the lid and allowing the air to have access to the arc.

The next thing to do was to try if an open arc could be made to hiss and the P.D. to diminish suddenly by blowing air at the crater, when the current was so small that the crater remained well at the end of the positive carbon—in fact, to bring the air in contact with the crater artificially when a much smaller current was flowing than would usually produce hissing. I first tried inserting a carbon tube in the arc, and blowing through it, but this almost invariably blew the arc out. Then Mr. Phillips, one of Prof. Ayrton's assistants at the Central Technical College, suggested using a tubular positive carbon and blowing the air down it. This plan answered admirably, for when a current of 10 amperes was flowing with an arc of about 3 mm., so that the arc was quite silent, each puff of air blown down through the positive carbon was followed by a hiss and the characteristic diminution of the P.D. between the carbons. With a current of 6 amperes, however, I could get no hiss, but simply blew the arc out each time, probably because, with such a small current, the arc was cooled sufficiently to be extinguished before the action could take place.

Oxygen was next tried, still with the open arc, and again each puff produced a hiss and diminution of the P.D., the latter being exactly the same in amount as when air was used, namely, about 10 volts. As my idea was that the diminution of the P.D. was due to the chemical combination of air with carbon at the temperature of the crater, the fact of oxygen producing the same diminution as air seemed to show that nitrogen would produce no effect, and that all the effect produced by air was due to the oxygen in it. Accordingly I tried blowing nitrogen down the positive carbon of an open arc, and found that *no* change in the P.D. followed if the nitrogen was blown through gently, but that, beyond a certain pressure, the arc was blown to one side, and thus lengthened, so that the P.D. *rose* as it always does when the arc is lengthened, and, if the pressure continued, the arc went out.

This experiment proved two things—firstly, that it is the *oxygen* in the air that causes the diminution in the P.D. with hissing; secondly, that this diminution is not due to cooling, for nitrogen would cool the arc as effectually as oxygen or air.

To make assurance doubly sure on this point, carbon dioxide was blown down the tubular positive carbon, with the same result as when nitrogen was used, viz. no change was produced in the P.D. between the carbons unless the pressure of the gaseous stream were large enough to blow the arc on one side, and then an increase and not a diminution in the P.D. was observed.

If, however, the current was *very near* the value that made an open arc of the particular length used start hissing, blowing either nitrogen or carbon dioxide through the positive carbon sometimes started hissing; but this was due, *not* to any direct action of the stream of gas on the carbon, but to the arc being deflected by the gaseous stream and burning obliquely up the side of the carbon, and thus allowing the air to come into contact with the crater. The proof of this was that this diminution in the P.D. had the same value as if air had been employed, and that the hissing did not cease when the stream of nitrogen or of carbon dioxide was stopped.

This was not the case with hydrogen, however. When that gas was blown down the positive carbon in the open air, the arc would start hissing, if the current were large enough, *and stop hissing the moment the hydrogen was shut off.* Not only this, but the diminution in the P.D. had a different value from

ARC ENCLOSED IN CRUCIBLE.

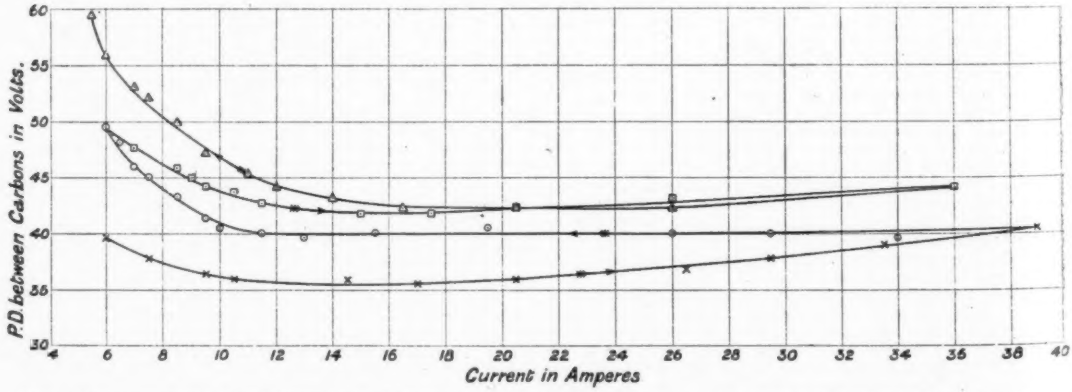

FIG. 9.—Curves connecting P.D. and Current for nearly Constant Length of Arc of 1·5 mm. to 2 mm. The arrows show the direction in which the Current was varied. Carbons:—Positive, 11 mm. Solid; Negative, 9 mm. Solid.

that produced by air, being only about 6·6 volts, or about $3\frac{1}{2}$ volts lower than when the hissing was caused by air alone.

In order to exclude all possibility of doubt as to the effect of the various gases, I repeated the experiments with the arc entirely enclosed in one of the fire-clay crucibles, so that the only gases that could reach the crater were those blown down the tubular positive carbon. The current was distinctly below the hissing point, being only 10 or 11 amperes, and the arc was from 2 mm. to 3 mm. long.

The results were exactly the same as with the open arc, except in the case of hydrogen. For air and oxygen produced hissing and a sudden diminution of the P.D., and nitrogen and carbon dioxide had no such effect, even when the current was very much increased. But whereas, as has been previously stated, hydrogen produced a distinct hissing of its own when blown down the positive carbon in the *open air*, it produced *none* when used in the same way with the arc *enclosed* in the crucible.

To prove that, in order to produce the sudden diminution of P.D. under discussion, it was necessary for the active gas to actually *touch* the crater, a tubular *negative* carbon was used, and each gas was blown up through it in turn, gently enough not to force the gas directly against the crater.

In *no* case was there any sudden diminution of the P.D., whatever gas was employed, and whether the arc was open or enclosed. On the contrary, there was generally a small increase, probably due to the lengthening of the arc by its being blown on one side. If oxygen or air were blown *very hard* up the negative carbon, they would either produce hissing, or blow the arc out, or both; for in that case some of the gas got to the crater uncombined with the carbon vapour, and acted exactly as if it had been blown do--n the tubular positive carbon.

The case, then, stands thus:

(1) When the arc begins to hiss in the ordinary way, the P.D. between the carbons diminishes by about 10 volts.

(2) If the air is excluded from the arc, this diminution of the P.D. does not take place, even when the current is nearly three times as great as would cause hissing in the air.

(3) If, however, while the air is excluded, puffs of air are sent against the crater, the diminution of the P.D. *does* occur, even with currents much *smaller* than would cause hissing in the air.

(4) If, instead of air, *oxygen* is sent against the crater, the P.D. is diminished to exactly the same extent as when air is used.

(5) If, on the other hand, *nitrogen* is sent against the crater, *no* diminution of the P.D. is observable.

(6) If air or oxygen is gently blown through the *negative* carbon, so that it cannot get direct to the crater, *no* diminution of the P.D. follows.

Thus there can be no shadow of doubt that *the sudden diminution of P.D. that accompanies the hissing of the open arc is due to the oxygen in the air getting directly at the crater and combining with the carbon at its surface.*

It only remains to show how the actual hissing *sound* may be produced by the burning of the surface of the crater. The moment this burning begins, a cloud of gas, formed of the products of combustion, must spread over the crater, protecting it momentarily from the action of the air as effectually as the carbon vapour had hitherto done. When this gas is dispersed, the air will again come in contact with the crater, a fresh cloud will form, and the whole action will start *de novo*. Thus a series of rushes and stoppages of the air will take place, setting up an irregular vibration of just the kind to cause a hissing noise. Not only this, however, but since the crater must cease to burn each time that it is protected by the gas, the diminution of P.D. must also cease to exist, since its cause is removed, and the P.D. will therefore rise momentarily. Thus an oscillation of the P.D. between the carbons, and, consequently, of the *electric* current, must be created, corresponding with the oscillation of the *air* current.

These oscillations of both air and electric currents do actually exist with the hissing arc. The first I have proved by means of a fine asbestos fibre fastened at one end to the hole in the crucible (Fig 8) through which the positive carbon moved. The asbestos ring was raised, and the space between the carbon and the crucible was left clear, and was made large enough to allow the free end of the short fibre to stretch out horizontally between the two. When the arc was silent, the fibre scarcely moved, but the moment hissing started it set up a vigorous vibration, instead of being sucked into the crucible as it would have been if there had been a steady inward current of air.

Messrs. Frith and Rodgers (*Phil. Mag.*, 1896, p. 420) showed, in 1896, that the *electric* current was oscillatory with the hissing arc, and Messrs. Duddell and Marchant (*Journ. Inst. Elec. Engs.*, vol. xxviii. p. 84) in the account of their beautiful experiments with the oscillograph, have given actual curves of the P.D. and current with the direct current hissing arc, showing distinctly the oscillations in both.

Thus the direct contact of the oxygen of the air with the crater of the positive carbon is capable of producing, not only the diminution of the P.D. between the carbons of the arc, which is the most striking accompaniment of hissing, but also every other important manifestation connected with it, including the sound itself.

HERTHA AYRTON.

THE INTERNATIONAL CONFERENCE ON HYBRIDISATION AND CROSS-BREEDING.

IN this country where the application of biological principles to the industries which they underlie is left as a rule to private enterprise or the half-hearted interest of County Councils, any means whereby the scientific worker is shown to be useful to the practical man is a help towards a better state of things.

For this reason alone the Conference on Hybridisation suggested by Mr. W. Bateson, and held on July 11 and 12, under the auspices of the Royal Horticultural Society, may have more importance in the future than Prof. Henslow claimed for it in the present. The more immediate results that will accrue are those which the Society foresaw must arise if the attempt to call forth papers, remarks and exhibits dealing with hybridisation was at all successful. Two days were not many to devote to the meeting, and it is a matter of surprise that such an amount of work was done in the time. When, however, the whole of the contributions, whether read or unread at the conference, are published in the form of an illustrated report, the Royal Horticultural Society should be more than satisfied.

Nevertheless the question of hybridisation is so large, as Mr. Engleheart said in the discussion, that "whole sets of subjects" (graft hybrids, for instance) could not even be touched upon, and the suggestion made in several quarters, but by the American delegates in particular, that a supplementary conference be held in another country should be taken up seriously.

Before discussing the chief points of the meetings it may be of interest to give a list of the speakers and their subjects.

Tuesday, July 11, in the Society's Gardens at Chiswick:—

(1) Maxwell T. Masters, F.R.S., Introductory remarks as Chairman.
(2) W. Bateson, F.R.S., "Hybridisation and Cross-breeding as a Method of Scientific Investigation."
(3) A. de la Devansaye, "Hybrid Anthuriums."
(4) Prof. Hugo de Vries, "Hybridisation as a means of Pangenetic Infection."
(5) The Rev. Prof. Henslow, "Hybridisation and its Failures."
(6) C. C. Hurst, "Experiments in Hybridisation and Cross-breeding."

Wednesday, July 12, at the Town Hall, Westminster.

(1) The Rev. Prof. Henslow, Introductory remarks as Chairman.
(2) Herbert J. Webber, "Work of the United States Department of Agriculture in Plant Hybridisation."
(3) Dr. J. H. Wilson, "The Structure of certain New Hybrids (*Passiflora, Albuca, Begonia*, &c.)"
(4) R. Allen, "Hybridisation viewed from the Standpoint of Systematic Botany."
(5) Henry de Vilmorin, "Hybrid Poppies."

(N.B.—Nos. 2 and 3 were illustrated by means of lantern slides, and No. 5 by large water-colour drawings.)

(6) Discussion; Prof. Henslow, Mr. Burbidge, Rev. G. H. Engleheart, Mr. George Paul, Mr. Bunyard, Dr. Masters, Mr. Willet Hays, and Mr. W. Cuthbertson.

The United States was represented by Mr. Herbert Webber, of the Department of Agriculture, his colleague Mr. Swingle, and Mr. Willet Hayes; France by MM. de la Devansaye

and Vilmorin; while among other "friends from across the sea" were hybridists from Germany, Holland and Switzerland.

With regard to the main body of our own countrymen who attended the conference, it must be said that horticulturists were very well represented, but that, with the exception of the readers of papers, biologists were few and far between.

Among papers of interest that were not read at the conference, but will appear in the report, the following may be mentioned:—

Prof. L. H. Bailey, "Progress of Hybridisation in the United States of America."
F. Morel, "Hybrids of *Clematis*."
P. Chappellier, "Essay on the Hybridisation of *Dioscorea*."
Émile Lemoine, "Hybrids of the Common and Laciniated Persian Lilacs."
L. Henry, "The Records of Hybridisation Experiments made at the Paris Natural History Museum between 1887 and 1899."
Charles T. Druery, "Fern Crossing and Hybridising."
Dr. Charles Stuart, "Hybrids of *Mimulus*, *Viola*, *Acquilegia*, &c."

During the first day's proceedings a fine show of hybrid plants and intergrafted genera was exhibited in the vinery at Chiswick.

Turning now to the material laid before the conference, it will be best to consider details under special headings.[1]

I. THE QUESTION OF SPECIES.

Significance of the Conception.—As the word hybrid ordinarily means the result of a cross between two species, it follows almost necessarily that the question of what a species is was several times raised. Prof. Henslow was so bold as to give a definition, saying that "it is known by a collection of presumably constant characters taken from any or all parts of the plant."

It is necessary to have some idea for working purposes, but Dr. Masters came rather nearer to the mark when he said that the species once considered sacred, to-day practically represented the personal opinion of some man who had paid special attention to it.

Mr. Bateson again still clung to the opinion that species were often definite, but breeding work alone, he said, could throw light upon the subject. He contended that this had already shown that under the title of species and varieties "whole sets of (physiologically) distinct phenomena are confused together," and taking it as proved that species arise from discontinuous variations, he gave three instances where the same deviation from type was kept up discontinuously, but in three different ways:—

(*a*) The hairy wild form of *Matthiola incana* from the Isle of Wight was crossed with the smooth wallflower variety of the stock.

The offspring fell into two groups, and from the same capsule came one hairy and three smooth plants.

(*b*) The usual hirsute type of *Lychnis vespertina* and the hairless form cultivated by Prof. Hugo de Vries were bred together.

The offspring were all hairy, but on being left to fertilise each other, the second generation gave some hairy, some smooth individuals.

(*c*) The variations of *Biscutella laevigata* which occur in Switzerland, one with hairs and the other without (connected by but few intermediate forms), were lastly joined together.

The offspring were glabrous or intermediate in character, but as they became adult the latter forms lost all their hairs.

The experiments quoted are some made by Miss E. R. Saunders, of Newnham College, Cambridge.

So-called Species sometimes Wild Hybrids.—The fact that a number of so-called species occurring in nature have been reproduced by the crossing of other wild species was considered by Mr. Rolfe as of interest to systematic botanists, who must now recognise wild hybrids and the work of hybridists.

So-called Species which are Garden Hybrids.—During the discussion Mr. Burbidge showed what great confusion had arisen through the giving of Latin names to garden hybrids of whose origin no record had been kept. Matters would not be improved, one would fancy, through the practice of some nurserymen whom Dr. Masters alluded to in his address, and who, in the earlier days of hybridisation, imagined a foreign locality for their own productions in order to overcome the prejudice then prevalent against hybrids. Mr. Burbidge's suggestion was to give no classical names to hybrids; but if perforce the habit must be continued, let such parts of the parents' names be conjoined as would indicate the origin of the new form. In his paper M. Lemoine traces the previously obscure origin of a lilac by hybridisation experiments; while M. Henry suggests that the conference should undertake similar work, and mentions a number of plants to begin with whose garden history requires elucidation.

II. THE LIMITS OF HYBRIDISATION AND CROSS-BREEDING.

In general.—Mr. Hurst gave statistics showing that up to date twenty-seven genera of Orchideæ, several belonging to different tribes as arranged by the systematic botanists, had been connected together by hybridisation. In other families so much has not been accomplished, but the same speaker noted five species of *Rhododendron* and four of *Gladiolus* that had been linked together. He said that the breeder might reasonably expect to be successful within the limits of a tribe; while, on the other hand, it was urged during the conference that an experiment is easy, and it is better to make it than to argue its non-success instead.

Dr. Wilson, in speaking of his results, said that he had hybrids of *Albuca*, in whose bodies five, if not more, original species were combined.

It can easily be seen that differences in structure may prove insurmountable barriers to hybridisation, but constitutional differences may often be disregarded. For instance, to quote Mr. Hurst, annuals can be crossed with perennials [M. de Vilmorin's poppies], deciduous trees with evergreens [Mr. Herbert Webber's oranges], plants from the tropics with plants from within the Arctic circle.

Special Cases.—Prof. Henslow discussed the question of some allied species which unaccountably will not cross, and he smilingly pointed out how much trouble would be saved if only one could tell plants' capabilities in the way of hybridisation from their outside appearance. Sometimes, he said, species of the same genus from different climates and habitats formed no hybrids, while even within the limits of a single species the red "geraniums" (*Pelargonium*) of France would not cross with English races; and certain strains of *Primula sinensis*, also mentioned by Mr. Hurst, and raised by Messrs. Sutton and Sons, were not fertile *inter se*.

Non-reciprocity.—Though many reciprocal crosses were recorded in the course of the conference, many failures, it was pointed out by the last-mentioned speaker, are known, but no further light was thrown upon the matter.

III. CROSSING A MATTER OF CONDITIONS.

Some one alluded to the fact that, whereas it might be found impossible to effect a cross with the earlier produced flowers of an inflorescence, say, yet hybrids could be easily obtained from the blossoms that opened later. In connection with this, Dr. Wilson's hybrid *Passiflora* might be mentioned, where the first flowers to appear contained coronal rays, or else a second and miniature ovary within the walls of the usual one; but in the case of the flowers borne near the ends of branches the pistils were normal. The way in which it was again and again reported that a hybridising experiment had failed for one, two, three, up to seven years shows that successful crossing must depend in a great measure upon at present unknown conditions of nutrition, acclimatisation, temperature, or something else.

IV. PREPOTENCY AND THE CHARACTER OF HYBRIDS.

Non-prepotency of Sex.—Where a hybrid appears to take after one parent in the more obvious and striking parts of its organisation it may resemble the other in more hidden but not less important characters (Mr. Hurst and M. Mael). Again, when species A, on being crossed with species B, produces hybrids that are practically replicas of itself ("false hybrids" of Millardet), it does not follow that the prepotent species, A, must necessarily be male or necessarily female (Henslow). Furthermore, reciprocal hybrids may be identical.

[1] For a *seriatim* account of the papers, see the *Gardeners' Chronicle*, series 3, xxvi. Nos. 655 and 656 (July 15 and 22).

Partial Prepotency.—This not very happy title is given by Mr. Hurst to a law which he puts forward as explaining, at least so far as the genus *Paphiopedilum* (= *Cypripedium*) goes, the varied results in the inheritance of characteristics. The law one takes to mean that in one part of an individual hybrid the mother, say, is seen to be prepotent; in another individual the same structure is inherited from the father; while in a third both parents are represented by an intermediate form of the special feature under consideration. We are then asked to imagine a real case where the combinations and permutations of all the component structures must be reckoned with. No doubt this brings the possibilities for variation very forcibly before us; but surely it is only giving another name to what must be expected whenever two parents representing two strains produce young. Although Prof. Ewart's zebra hybrids were mentioned by Mr. Hurst in another connection, yet little heed was given by any one to the possibilities of hybrid plants throwing back to ancestors in the dim past, as undoubtedly appears to be the case with animals.

Prepotency of Varieties, Species, and Genera.—Mr. Hurst's paper, which, indeed, was the only one that in any way systematically attacked the broad headings of hybridisation, contained much information deduced from the Orchideæ as to the inheritance by hybrids of the characters which are commonly valued as varietal, specific and generic. As might be imagined, the generic are most difficult to efface; the specific again are less lasting but more persistent than varietal, which are fleeting. Mr. Hurst had, however, to allow that distinct variations may transmit their qualities, and it would be difficult for him to do otherwise in the face of Mr. Bateson's examples; he gave exceptions, which he said are by no means rare—these come in when the variations are slight or the ancestry variable, and an abnormality he found to be transmitted either wholly or not at all. The case given by Prof. Hugo de Vries of the twisted variety of teasel (*Dipsacus sylvestris*) when crossed with *Dipsacus fullonum* being prepotent as regards the abnormality, exemplifies the former of these two alternatives. Prof. de Vries, it should be called to mind, explains it as a case of pangenetic infection. Finally, Mr. Hurst said that when the same variations are found in both strains, they may be traced in the second or following generations, but seldom otherwise. Prof. Vries' second experiment is at first opposed to this; but the latter stage confirms it. He desired to obtain artificially a hairless variety of *Lychnis diurna*, similar to one found in nature, and known as *L. presli*. To do this he crossed the ordinary hirsute variety with his glabrous form of *L. vespertina* already mentioned, and the hybrids were all uniformly hairy. The offspring of these again showed the characters of one or both parents in all degrees. Taking two glabrous examples and crossing them, a constant variety of *L. diurna* without hairs was forthwith obtained, starting with a batch of 390 plants, all glabrous.

Parthenogenesis and Polyembryony.—Prof. Henslow, among the many interesting details which he contributed, mentioned how pollen tubes are sent out even when the pollen of a pea is placed upon the stigma of a lily, and how on more nearly allied forms, although no fertilisation may take place, yet the irritation is enough to cause the empty ovary to swell and appear to contain seeds in a way comparable to the formation of galls (partial hybridisation). To explain cases where in crossing a species of one Orchid genus with others, *e.g. Epidendrum* with *Cattleya*, *Laelia* and *Sophronites*, the first was completely prepotent, Mr. Hurst advanced the theory that the occurrence was due to a kind of parthenogenesis, the pollen encouraging the egg-cells to develop into seeds without absolutely having the power to fertilise them.

A difficulty met with in the raising of hybrid races of oranges, which Mr. Webber described, is due to the fact that in the genus *Citrus*, adventitious embryos arise from the cells of the nucellus outside the embryo sac containing the normal egg. The result is that the latter only is affected by pollen, and from the seed arise several seedlings as shown in lantern pictures, only one of which can be the hybrid, the others reproducing the mother plant exactly.

Vigour.—The exceptional growth of hybrid plants being a well-known phenomenon was referred to again and again, and was put down by Mr. Hurst to the effect of out-crossing, as inbreeding he found in his experiments reduced the vigour at once.

Diminution of Fertility.—Dr. Wilson's results point to this being due to the poor development of pollen, and the lessened fertility of the male was shown by Mr. Hurst's statistics for *Paphiopedilum*. Of crosses in this genus between pure species 95·05 were successful; hybrids fertilised with pollen from pure species produced seeds in 91·82 per cent. of the cases; while pure species were only fertilised by the pollen from hybrids in 60 per cent. of the experiments. The case of male elephants being usually sterile in captivity seems worthy of mention in this connection. Mr. Hurst's generalisation that diminution of fertility is due to conditions of life rather than to any difference in the form or constitution of hybrids gains support, which is added to by the evidence given above under the headings II. (*Special cases*) and III.

Microscopic Structure.—Allusion was made to Dr. Macfarlane's work on the structure of primary hybrids, but what little was said about the microscopic conformation of secondary hybrids in *Albuca* (Dr. Wilson), and in *Rhododendron* (Prof. Henslow in the discussion), points to their possessing no internal characters of the importance of specific ones.

Hybrid Races.—That secondary hybrids differ more than primary ones from the parent species was the opinion of M. de la Devansaye and Mr. Hurst, and the latter speaker gave a series of figures showing the stability of the former kind; for out of 500 seedlings of a hybrid *Berberis*, 90 per cent. reproduced the immediate parent form, while in no instance was there complete reversion to either of the grandparent species. It is possible that many of our so-called wild species are stable hybrid races.

V. THE ECONOMIC SIDE OF HYBRIDISATION.

Mr. Webber, in his remarks, and Prof. Bailey, in his paper, both told the same tale with regard to the United States. The bulk of the hybridisation on the other side of the Atlantic is carried on with a view to producing plants that will stand the particularly disadvantageous conditions of frost and drought, and so on, that occur in the wide tracts of land that must be cultivated, or to improving the yield or quality of special vegetable productions upon which many persons depend for their living. Ornamental hybrids are bought for the most part in Europe. The Government does a great part of the work of production, and the experiment stations carry out the work of testing new varieties, be they privately raised or otherwise, which at the same time allows the growers to see the value of the plants before they are distributed. Mr. Hays, in the discussion with regard to the little benefit accruing in this country to the raiser of a new plant, pointed out the opportunity given in America by the system just described for the said plant to be taken up. The Rev. G. H. Engleheart, as an amateur, and Mr. George Paul, as a nurseryman, talked of legislation whereby some sort of copyright should be established in new varieties. Mr. Bunyard pointed out objections, and showed how a man might raise sufficient stock before parting with any to ensure a profit he had calculated beforehand. This presupposes a fairly large sale, and might not be possible to the grower in a small way of business. Mr. Engleheart also alluded to there being no book in which the scattered facts so useful to the hybridist had been brought together.

Perhaps the time will come when there may be State authorities in this country to consider the scientific side of horticulture (as well as entomology and fisheries) in a modern way. At present the annual examination of the Royal Horticultural Society, upon the results of which certificates are granted, includes a theoretical test not only on the practical but on the scientific side. This certificate is the only recognised one which the gardener can obtain, and its value would be much enhanced if the examination were accompanied, or say followed, in the case of candidates who obtain a sufficient number of marks, by a practical examination in both branches of the subject.

WILFRED MARK WEBB.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

MR. W. A. HOUSTON, has been appointed to the post of assistant lecturer in mathematics in University College, Liverpool.

THE Agriculture and Technical Instruction (Ireland) Bill was read a third time in the House of Commons on Monday, and a first time in the House of Lords on Tuesday.

THE *University College School Magazine* announces that Mr. R. Tucker, who has guided the mathematical fortunes of the

school since 1865 with great success, will retire from his post at the close of this session.

DR. W. SOMERVILLE, professor of agriculture and forestry at the College of Science, Newcastle-upon-Tyne, in connection with the University of Durham, has been elected to the new professorship of agriculture in Cambridge University.

PARTICULARS concerning British, Continental and Canadian Universities, with special reference to institutions having courses open to women, are given in a "Handbook" compiled by Dr. Isabel Maddison for the Graduate Club of Bryn Mawr College, and published by the Macmillan Company, New York. We notice that Queen's College, London, which celebrated its jubilee last year, has been omitted. As the volume is primarily intended to indicate colleges for women students, the omission of a college of this kind possessing a Royal Charter is unfortunate.

THE departmental committee appointed by the Lord President of the Council to consider the question of the reorganisation of the Education and Science and Art Departments consists of Sir Horace Walpole, K.C.B (chairman), Sir G. W. Kekewich, K.C.B., Secretary of the Education and Science and Art Departments, Captain W. de W. Abney, C.B., principal assistant-secretary of the Science and Art Department, Mr. S. Spring Rice, C.B., of the Treasury, and Mr. W. Tucker, C.B., principal assistant-secretary of the Education Department.

THE ninth summer meeting of University Extension Students will be opened at Oxford on July 29. Many prominent members of the University have arranged to take part in the meeting. In the scientific section Prof. Gotch will deal with "The Physiology of Sensation," Prof. Sollas will lecture on "The Geology of Oxford," Prof. H. A. Miers on "The Growth of a Crystal," Mr. H. N. Dickson, New College, on "The Influence of Climate," Mr. G. C. Bourne, University lecturer in Anatomy, on "The Growth of the Living Organism," Mr. G. J. Burch on "Wireless Telegraphy," and Dr. Arthur Ransome on "Microbes and Disease."

MR. A. F. STANLEY KENT has been appointed professor of physiology in University College, Bristol. Mr. Kent received his scientific training at Oxford, which he left upon being appointed demonstrator of physiology in Owens College, Manchester. In 1889 he was invited by Sir J. S. Burdon-Sanderson to take charge of the histological department at Oxford, to lecture on special points in physiology, and to assist in the teaching of general physiology. Since 1892 he has been assistant lecturer in physiology and histology at St. Thomas's Hospital, and has carried out a number of researches, the results of which have been published in various journals, proceedings, and reports.

SECONDARY as well as elementary schools are now beginning to appreciate the advantage of having upon their staff one or more teachers who thoroughly understand the application of the theory and practice of hygiene in school life; and the desirability of emphasising the necessity of this knowledge in the code for elementary schools is now being pressed upon the Education Department by memorials from several important bodies. To encourage the systematic study of the subject, the Council of the Sanitary Institute have decided to arrange a thorough theoretical and practical examination, which will be open to both classes of teachers and to those preparing as teachers. The first examinations will be held during February and June next year.

THE first of a series of articles dealing with the provision made by local authorities for the technical education of miners appears in the July number of the *Record* of Technical and Secondary Education, the information given having reference to the County Councils of Cornwall, Durham, Northumberland, and the West Riding of Yorkshire. The permanent schools of mining in Cornwall are at Camborne and Redruth, in the centre of the Cornish mining district, and they thus afford exceptional facilities for the acquisition of a practical as well as a theoretical knowledge of mining and its allied subjects. As regards the provision of practical work other than that concerned with elementary scientific principles, the Committee of the Redruth School have made arrangements with the managers of neighbouring mines for the practical instruction of the students. The Committee of the Camborne School adopt the same system to some extent, but are also themselves the owner of a portion of a mine, having purchased the same in 1897 for the use of students. Cornwall thus furnishes a unique instance of educational procedure by reason of this purchase of a mine by a local school committee.

As the result of a conference between representatives of the London School Board and London County Council, having for its object the prevention of overlapping of classes, the representatives of the former body have resolved to recommend the Board to adopt the following proposals among others:—(1) The School Board will limit its instruction in science and art in all its evening schools to such grades as can be conveniently taught in its premises, and will look to the Technical Education Board to give the advanced instruction in the premises under their control. (2) The School Board will not conduct classes in technological subjects, and will not offer instruction specially intended for university degrees. (3) The School Board proposes to conduct preparatory classes in elementary experimental science, in elementary freehand, geometrical, and model drawing, and in the drawing of simple pieces of mechanism; in mensuration and workshop arithmetic, and in algebra, to enable pupils to understand the meaning of an algebraical formula. (4) The School Board proposes to conduct evening classes in manual training, woodwork, and metal-work as part of a general education, and as preparatory to commercial workshops, but to refer students who are members of specific trades, and require trade teaching, to the Polytechnics and Technical Institutes.

SCIENTIFIC SERIALS.

Symons's Monthly Meteorological Magazine, July.—Meteorological extremes: Pressure. Mr. Symons has undertaken to give, in alternate numbers, a list of extremes of the various meteorological elements. The task is by no means easy, as the information is scattered, in many books and languages, and some of the statements will no doubt lead to useful criticisms. The highest recorded barometric pressures (reduced and corrected) are 31·78 inches at Irkutsk, January 14, 1893; 31·72 inches at Semipalatinsk, December 16, 1877; and 31·62 inches at Barnaul, December 14, 1877. Dr. Woeikof doubts the accuracy of the first reading, *inter alia*, because the temperature for reducing *up* to the freezing point had been taken at $-51°·34$ F., and had been assumed to prevail from Irkutsk to the sea. He maintains that the reading of 31·62 inches at Barnaul is really the best established barometrical maximum as yet on record. The reduction to sea-level from stations some thousands of miles from the nearest sea renders the statements more doubtful than readings taken near the sea-shore. The highest readings in the British Isles are 31·108 inches at Octertyre, and 31·106 inches at Fort William, both on January 9, 1896. The highest reading in the neighbourhood of London since 1858 (the date of commencing observations at Camden Square) is 30·934, January 9, 1896. The lowest pressures are those referred to in NATURE, vol. xxxv. p. 344, viz. 27·135 on September 22, 1885, at False Point on the coast of Orissa. In the *Quarterly Journal* of the Royal Meteorological Society, vol. xiii. p. 212, Mr. C. Harding pointed out that for comparison with English standards a further subtractive correction of ·011 inch has to be applied, which would make the lowest reading 27·124 inches. The next lowest reading occurred at Octertyre on January 26, 1884, viz. 27·332 inches. The lowest reading at Camden Square is 28·295, December 9, 1896.

Bulletin of the American Mathematical Society, July.—The asymptotic lines of the Kummer surface, by Dr. J. I. Hutchinson, was read at the April meeting. These curves have been discussed by Klein and Lie, Reye, Segre and Rohn from the point of view of line geometry. This notelet gives a simple solution by making use of the parametric representation of the Kummer surface in terms of hyperelliptic functions.—On a definitive property of the covariant, by C. J. Keyser, was read at the same meeting. The writer refers to three proofs, due to Jordan, Elliott and Fiske respectively.—Yet another paper read at this meeting was the known finite simple groups, by Prof. L. E. Dickson. This is in part a *résumé* of previous work done by the author, and gives a table which should aid in the determination of the status of a newly-discovered simple group.—Reviews follow, viz. of Schoenflies' "Geometrie der Bewegung in Synthetischer Darstellung," and of Speckel's "La Géométrie du Mouvement Exposé: Synthétique," by Prof. F. Morley; a short notice of the second edition of the second volume of Weber's "Lehrbuch der Algebra," by Prof. Pierpont. Shorter notices

are Teixeira's "Corso de Analyse infinitesimal: Rudio's Verhandlungen der ersten internationalen Mathematiker-Kongresses in Zürich," vom 9 bis 11 August, 1897; Klein's lectures on the mathematical theory of the top; Moritz Cantor's "Politische Arithmetik oder die Arithmetik der täglichen Lebens"; and Virgilii and Garibaldi's "Introduzione alla Economia Matematica."—Prof. J. Pierpont gives a short note on elliptic functions, which discusses the simplest and most natural way of presenting the theory.—Notes, new publications as usual, and the index follow.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, June 15.—"A Preliminary Note on the Morphology and Distribution of the Organism found in the Tsetse Fly Disease." By H. G. Plimmer and J. Rose Bradford, F.R.S., Professor Superintendent of the Brown Institution. (From the Laboratory of the Brown Institution.)

These observations are the result of an inquiry entrusted to us by the Tsetse Fly Committee of the Royal Society, at a meeting of the Committee on March 16, 1899.

The material for our investigations was obtained in the first place from a dog and a rat, inoculated with the blood of a dog suffering from the disease, by Mr. H. E. Durham, at Cambridge.

The organism found in the Tsetse Fly disease was discovered by Major Bruce, R.A.M.C., F.R.S., and was classed by him as a Trypanosoma. These belong to the order Flagellata, and, according to Bütschli, to the sub-group Monadina.

We will, in the first place, describe the adult form of the organism, such as is met with most frequently in the blood of a susceptible animal affected with the disease.

A. *Description of the Adult Form of the Trypanosoma.*

In freshly drawn blood examined as a hanging drop, or as a very thin layer in a cell, the adult form of the Trypanosoma can be easily studied. The latter method is the better, as the organism can be better seen and more accurately examined, in the thin, uniform layer of fluid than in the rounded drop. The easiest method of examining the blood in this way is to make, with a red-hot platinum loop and a small piece of paraffin, a thin ring of paraffin on an ordinary glass slide; the drop of blood is placed in the centre of the ring and a cover-glass placed on it, the thin layer of paraffin preventing pressure. If it be desired to keep the blood for continuous examination, it should be drawn into a graduated Pasteur pipette, and one-tenth part of a 5 per cent. solution of sodium citrate should be drawn up after it, then the blood and citrate solution should be carefully mixed in the bulb; the tube should then be sealed up, and drops can be taken from it as desired.

Under ordinary conditions of illumination the Trypanosoma, as seen in the blood, appears to consist of a uniform, homogeneous mass of protoplasm, of worm-like form, with at one end a thick, stiff extremity, and at the other a long, wavy flagellum. It is generally in active motion, and this is seen to be caused by the rapid lashing movement of the flagellum, and by the rapid contractions and relaxations of the mass of protoplasm forming the body, and by the movements of an undulating membrane which is attached to one surface of the body, and which appears to undulate synchronously with the contractions of the protoplasmic body. This membrane is, excepting at the free edge, very transparent, and can be seen much better in citrated blood which has been thickened by the addition of a small drop of 1 per cent. gelatine solution, when its contour and attachments can be much better made out, owing to the slower rate of vibration effected by the thickened medium.

The general shape of the Trypanosoma, when rendered quiescent by this means, but not killed, is that of a long oval, with one end blunt and the other continued into the flagellum; the membrane is then seen to be attached to one side of the body; it begins a little in front of the blunt end of the organism, and is continued at the end into the flagellum.

But with better illumination, such as a very oblique pencil of rays, or, better still, with monochromatic light (green or blue), the protoplasm is seen not to be homogeneous. The organism appears then as a highly refractive body, and near the middle, or between it and the flagellate end, is seen a large dark body much more refractive than the rest of the protoplasm; this is the macronucleus. Near the thick, stiff end of the body a tiny still more refractive body (with monochromatic light nearly black) is seen, which is the micronucleus. The addition of a drop of 5 per cent. acetic acid makes both of these bodies much more distinct. At the stiff end of the Trypanosoma, in varying relation to the micronucleus, is seen a vacuole. There is no suggestion of a mouth or of any organs, but the protoplasm with the most careful illumination appears not to be uniform, which suggests an alveolar structure, as described by Bütschli. With the ordinary simple stains (hæmatoxylin, fuchsin, methylene-blue, thionin) the differentiation is not much better than can be observed by careful illumination of living unstained organisms, as these stains are with these, and similar organisms, too diffuse to be of any service. Acting on a method which Ehrlich originated in 1889, and which Romanowsky modified in 1891, and which has still been further elaborated by Ziemann in 1898, we have used a mixture of methylene-blue and erythrosin, which has enabled us to follow the different stages of the Trypanosoma with certainty. This method depends on the fact that when a basic and an acid stain are mixed together in certain proportions, a third neutral body is formed, which has a specific colour reaction with chromatin. By the use of this method we have been able to trace the various stages of the organism in the blood and organs of the affected animals, which is not possible with the ordinary stains, these being useless for many of the forms to be presently described. With this method the macronucleus of the Trypanosoma is stained a clear, transparent, crimson lake, the micronucleus a deep red, and the protoplasm a delicate blue; these reactions are constant throughout all the stages of its life-history.

The protoplasm of the adult Trypanosoma does not stain uniformly, as does that of some of the other forms, but there are parts faintly stained and parts unstained, which is again in favour of the alveolar structure mentioned above. The vacuole is quite distinct as a clear round space when the organism is stained by this method.

The macronucleus is generally of an oval or elongated shape, and it may be either uniform in colour, or in the form of fine threads; this latter is seen especially in those forms which show other signs of division. The micronucleus is seen as an intensely stained round dot, or as a short rod, this latter form again being seen in those forms which show other signs of approaching division. With the highest powers (1·5 apochromatic objective and 18 compensating eyepiece of Zeiss) we have not been able to make out any special structural characters in this body. The flagellum is not stained by this method, but if the preparation has been well fixed, it is easily visible; the vibratile membrane also is unstained, and can be generally better studied in specimens stained by simple stains, preferably thionin.

As regards the movements of the organism, in preparations where no pressure is exercised, they can be seen moving either with the flagellum or with the blunt end in front; but we think that the commoner mode of progression is with the flagellum forward.

The size and length of the body varies very much with the period of the disease at which the blood is examined and with the kind of animal. The largest forms we have seen have been in rats' blood, just after death, and the smallest in rabbits' blood, early in the disease.

B. *Distribution of the Trypanosoma.*

(1) *In the Body of Normal Animals.*

(*a*) *In the Blood.*—We have found the flagellate form in the greatest numbers in the blood of the mouse, towards the end of the disease. In the rat also they occur in great numbers, and in both these animals they can be found in the blood on the fourth or fifth day. In the dog large numbers can be seen in the blood from the sixth day. In the cat they are fewer in number in the same lapse of time than in any of the animals before mentioned.

The rabbit seems to be the most refractory animal of any we have as yet used, and the Trypanosoma are found in the blood in small numbers only, and at very uncertain intervals.

(*b*) *In the Lymphatic Glands.*—In the superficial glands nearest to the point of inoculation the flagellate organism can be found earliest. In the rat the Trypanosoma can be found in the nearest superficial gland in twenty-four hours after inoculation. We have not found that generalisation of the organism in the lymphatic glands occurs until nearly the end of the disease, when the organism is present in very large numbers

in the blood. In the rabbit, in which the organisms are few or rare in the blood, the glands do not show any marked change, and the Trypanosoma are not readily found in them. Many other forms are found in the glands, to which reference will be made below.

(*c*) *In the Spleen.*—The adult Trypanosoma is found in but small numbers in the spleens of the various animals we have examined; but other forms are found there which will be described later. The enlargement of the spleen is *post mortem* the most obvious fact in the morbid anatomy of the disease; it may attain even to four or five times the average volume—this is especially the case in the rat.

(*d*) *In the Bone-marrow.*—We have found either very few flagellate organisms, or none at all, in the bone-marrow of the various animals we have worked with. The marrow is altered in colour and structure, but there does not seem to be a greater number of Trypanosoma than can be accounted for by the blood in the marrow.

In the other organs and parts, the number of organisms present depends upon the relative quantity of blood in the part.

(2) *In the Body of Spleenless Animals.*—As the spleen in the ordinary animals is the organ which is most obviously altered in this disease, we have made a series of inoculations into animals (dog, cat, and rabbit) from which the spleen had been removed a year ago. In the dog, the adult forms of the Trypanosoma are not found so early in the blood of spleenless as in that of ordinary animals (seventh day as compared with fourth day after inoculation). The glands, after death, are much more generally enlarged, and are reddish in colour, and contain many more organisms than in the normal animal. Both the blood and glands contain, however, numerous other forms to be described below.

This marked difference in the colour of the glands of spleenless animals is probably due to the removal of the spleen, and the glands consequently taking on some of the splenic functions.

The bone-marrow is much altered, and in it likewise are found a large number of Trypanosoma, both flagellate and what are termed below "amœboid" forms.

In the cat the conditions of experiment were altered, the blood (1 c.c.) from the infected animal being introduced, with every precaution to avoid contamination of the tissues, direct into the jugular vein. In this case the organism appeared in the blood in numbers on the fourth day, and the animal died on the twelfth day. As the Trypanosoma were introduced into the blood stream direct, there was no marked glandular enlargement, but the glands were all reddish in colour, the change in colour being due to the spleenectomy. A few adult organisms were found in the glands and in the bone-marrow.

In the spleenless rabbit a few Trypanosoma have been found in the blood on two occasions, but the animal lived nearly two months, and notwithstanding the failure to detect adult flagellate forms in the blood on numerous occasions, the blood was always infective, and contained numerous forms termed "amœboid" and "plasmodial" below.

C. *Infectivity.*

(*a*) *In Ordinary Animals.*—The blood and organs of an animal dead of the disease lose, before twenty-four hours after death, their infective power. This is apparently due to the rapidity with which decomposition sets in after death, as we have found living Trypanosoma in film preparations, made as described above, as long as five to six days after removal of the blood from the body; and we have also found that large quantities (200 c.c.) of blood removed from the body into a sterile vessel and kept in an atmosphere of oxygen, retain their virulence for at least three days, notwithstanding the fact that the flagellate form cannot be demonstrated.

We have found that the blood of the dog is infective at least two days before any adult Trypanosoma can be seen in the blood; and we have also found that the blood of the spleenless rabbit, in which we have only on two occasions seen any adult forms, is invariably infective. This, of course, suggests the idea that the organisms must be present in another form, and we have been able, by the use of the method of staining described above, to demonstrate the presence of other forms in the blood and organs, and have shown, by the experiments just mentioned, that the infectivity of the blood, in cases where there are no flagellate forms discoverable, depends in all probability upon the presence of one of the other forms which the Trypanosoma assumes.

Although a differential staining method, such as the one we have used, is necessary for following and demonstrating the various stages of the life-history of the Trypanosoma, still these stages can be seen in unstained living specimens, with very careful illumination. As a matter of fact, our first observation of them was in unstained preparations.

In the blood of the dog, cat, rabbit, rat, and mouse, besides the adult forms as described above, which, as mentioned, are very various in size, there are adult forms undergoing division, both longitudinal and transverse, to which reference will be made later. Also two organisms are sometimes seen with their micronuclei in close apposition, or fused together, with more or less of their bodies also merged together. Such forms we believe are conjugations. Again, there are other large forms, with or without a flagellum, in which the chromatin of the macronucleus is broken up into a number of tiny granules, not bigger often than the micronucleus. Besides these there are other forms, which we call for convenience here "amœboid" forms, by which term we mean single, small, irregularly shaped forms, with or without a flagellum, but always with a macro- and micro-nucleus. These nuclear structures are generally surrounded by a very delicate envelope of protoplasm, of greater or lesser extent, but occasionally forms are seen which seem to consist only of chromatin, with or without a flagellum. Besides these, again, there are other forms which we call, also for convenience, "plasmodial" forms, meaning thereby an aggregation or fusion of two or more amœboid forms. In the blood these plasmodia are not generally very large, but may show evidence of from two to eight separate elements. Signs of division are very common; but in the blood one does not often meet with a plasmodium dividing up into more than four organisms of the adult shape. The plasmodial form also retains intact the two nuclear structures—the macro- and micro-nucleus—which we believe divide in the plasmodium, thus increasing its size.

In the spleenless animals the blood may contain no forms but the amœboid and plasmodial, such as is the case in the rabbit, yet this blood is infective; moreover, in the dog, before the adult organism appears in it, the blood is infective, and therein, at this period, these plasmodial forms can be demonstrated. In the glands these plasmodial forms are found, but only in quantity in those animals from which the spleen has been removed.

The spleen is the organ which shows these forms in the greatest abundance. The whole spleen is crammed in every part with plasmodia, which are wedged in between the splenic cells in every direction: many amœboid forms and also immature flagellate forms are also seen, but the most striking thing is the enormous quantity and uniform distribution of the plasmodia. The great enlargement of the spleen, which we have found constant in all the animals we have used, is caused by this mass of plasmodia, which we have found in the spleen within forty-eight hours from the time of inoculation.

In the marrow these plasmodial forms are only found, so far as our experience goes, in those animals from which the spleen has been removed. In these cases there are both plasmodial and amœboid forms in the marrow, the latter the more abundant.

The principal differences in the distribution of the plasmodial forms in animals with and without spleens is this: that in the animals with spleens the organ of choice for the plasmodia is the spleen, but they are also found constantly in the blood, and in less quantity in the glands, whereas in animals from which the spleen has been removed the plasmodial forms are plentiful in the blood, the glands, and the bone-marrow.

D. *Life-History of the* Trypanosoma "Brucii."

Besides the forms mentioned above, we have seen in the blood and in the organs divisions of the adult form, both longitudinal and transverse, the former the more frequent; but we think that this direct mode of reproduction is far less common than the indirect by means of conjugation (probably), breaking up of chromatin, production of amœboid forms, with subsequent division of these amœboid forms, and the formation of plasmodia by the aggregation or fusion of the amœboid forms, and these finally giving off flagellate forms, at first small, and gradually increasing up to the normal adult form.

So that we should tentatively summarise the life-history of the Trypanosoma found in Tsetse Fly disease, which we think might properly be called "*Trypanosoma Brucii*," in recognition

of the work done in connection with it by its discoverer Major Bruce, F.R.S., as follows:—

(1) Reproduction by division, this being of two kinds:—

(*a*) Longitudinal, the commoner.
(*b*) Transverse, less frequent.

(2) Conjugation, consisting essentially, so far as our observations go, of fusion of the micro-nuclei of the conjugating organisms.

(*a*) After this we are inclined to place those forms mentioned above, in which the chromatin is broken up, and scattered more or less uniformly through the whole body of the Trypanosoma, since this occurs after conjugation in other organisms not far removed biologically from this one. The next stage in our opinion is the amœboid; we think that the flagellate form becomes amœboid perhaps after conjugation, but also probably apart from this process.

(*b*) Amœboid forms. These are found with and without flagella, of various shapes and sizes, but always possessing a macro- and micro-nucleus. These forms are constantly seen in the process of division, and sometimes are very irregular in shape, with, in this case, an unequal number of macro- and micro-nuclei, the latter being the more abundant. The amœboid forms then fuse, or aggregate, together to form—

(*c*) The plasmodial forms. Whether these are true plasmodia, or whether they are only aggregations of amœboid forms, it is not yet possible to say, but as many related organisms form true plasmodia we are inclined to look upon these masses, provisionally, as true plasmodia. In the spleen these plasmodia reach a large size. From these again are given off—

(*d*) Flagellate forms, which increase in size, and become the ordinary adult form. Small flagellate forms are not infrequently seen in process of separation from the margin of these plasmodial masses.

Besides these forms we have observed frequently, especially in rat's blood after death, the adult forms arranged in clumps. They appear, upon watching them for a considerable time, to get tangled together to form a large writhing mass; then the movements become gradually slower in the centre of the mass, and are only seen at the periphery. At this stage, if the specimen be fixed, the mass appears to be made up of a quantity of macro- and micro-nuclei, as the protoplasm does not stain, except in the organisms at the periphery, *i.e.* those which have arrived latest. Eventually these, too, become motionless, and the mass becomes an indistinct collection of granular matter, which is not infective, so that we look upon these tangles as a proof of death.

Since these observations were made, there has been published an important paper on the Rat Trypanosoma, by Lydia Rabinowitch and Walter Kempner in the *Zeitschrift für Hygiene*, vol. xxx. part 2. We have been able to confirm many of the observations and statements as to the morphology and reproduction of the Trypanosoma made by these writers. But there is no mention made of the plasmodial stage, or of any reproductive stage elsewhere than in the blood; and the writers recognise only three methods of reproduction, namely, longitudinal and transverse division, and division by segmentation. This segmentation, they consider, arises from *one* organism, and they state that it may divide up into as many as ten to sixteen elements. This segmentation form would seem to correspond to our plasmodial stage, but we have seen much larger masses than those mentioned above, and they do not notice the enormous masses of plasmodia which infiltrate the spleen in every direction, and which can be found also in glands and marrow. Moreover, their amœboid stage (Kugelform) would precede the segmentation form, and therefore the "Kugelform" should be much larger than the ordinary adult form, but we have observed that, as a rule, our amœboid forms are very much smaller than the adult forms, some not being visible with any but the highest magnifying powers; so that we have been unable to accept this form of division by segmentation, except in the form in which we have described it above, *i.e.* our plasmodial stage.

EDINBURGH.

Royal Society, July 3.—Prof. Copeland in the chair.—A telegram from Lord Kelvin was read on magnetism and molecular rotation. An electrified body is set into rotation by the generation of a magnetic field around it. The magneto-optic phenomena discovered by Faraday, Kerr, and Zeeman are to be thus explained.—Prof. Tait communicated a paper by Prof. C. N. Little on the non-alternate ± knots of the tenth order. The characteristic of non-alternate knots is that, as we pass round it, the crossings do not always come alternately above and below. The simplest non-alternate knot is one of eight crossings; and Prof. Little has now carried the census of these knots as far as the tenth order.—Prof. Sir W. Turner read a paper on contributions to the craniology of the people of the Empire of India: Part I. "The Hill Tribes of the North-east Frontier and the People of Burmah." Certain of the skulls which were shown, and discussed in detail, came from the Lushai-Chin region, and were, with few exceptions, of the dolichocephalic type. Yet the features of these people are distinctly Mongolian; and the typical Mongolian skull is brachycephalic. The same peculiarity was shown in eight skulls which Surgeon Lieut.-Colonel Wright had sent from the Naga Hills north of Manipur—the skull being dolichocephalic but the features Mongolian, and therefore usually belonging to the brachycephalic type. On the other hand, the Burmese skulls, which had been supplied by Surgeon Captain Bannerman and Surgeon Major Bell, were, with two exceptions, brachycephalic.—Sir William Turner also read a paper on decorated and sculptured skulls from New Guinea. These had all come from British territory. The sculptured skulls were of special interest, the sculpturing in all cases being executed on the frontal bone. Sir William distinguished five distinct types of sculpturing, and threw out various speculations as to their significance.—Dr. Hepburn described and exhibited an improved form of craniometer for the segmentation of the transverse, vertical, and antero-posterior diameters of the cranium. In this improved form of cranial calliper, the graduated bar has zero at its centre, and the two curved legs of the callipers are both movable, each along its own half of the bar, which is graduated from the centre outwards. At the centre of the bar a straight calliper leg is introduced, being sunk in an undercut groove so that it may be adjusted to any required convenient length. The instrument may be used as an ordinary calliper by removing the centre limb, clamping the one calliper leg, and reading on the reverse side of the bar, which is graduated continuously from end to end. In using the improved form, we place the point of the central limb on any desired spot, and adjust the two curved limbs until they touch the ends of the chord to be measured. The measurements give, not only the length of chord, but also indicate the amount of asymmetry. The instrument had been tested on a number of skulls of various human races and of anthropoid apes. The relative heights of cerebrum and cerebellum had been determined, the position of the occipital condyles in relation to the greatest length had been studied, and a variety of other results obtained. In all such measurements the dolichocephalic skulls came nearer to those of the anthropoid apes than the brachycephalic skulls.—Mr. J. Y. Buchanan read a paper on the meteorology of Ben Nevis in clear and in foggy weather. The days in which the mountain was enveloped in cloud were first separated from the days when a clear atmosphere prevailed, the minimum of foggy weather being taken as three consecutive days, and the minimum of clear weather as twenty-four consecutive hours. As was to be expected, the foggy weather contained all the worst weather, and the clear weather all the best. Also in foggy weather the barometer was, on an average, half an inch lower than in clear weather.

July 10.—Prof. Copeland in the chair.—At the request of the Council, Prof. Cargill G. Knott gave an address on earthquakes, their propagation through the earth, and their bearing on the question of the earth's internal state. A brief sketch of the history of earthquake research was followed by an account, illustrated by lantern slides, of the various forms of seismographs, seismoscopes, seismometers, tromometers, &c., which have been devised, more especially in Italy and Japan, for the recording of the gentler types of earthquakes, and of seismic vibrations too feeble to be perceived by our senses. This led to a discussion of the main characteristic of those minute vibrations which have their origin at an earthquake focus, and pass across thousands of miles to be recorded on suitable instruments at localities not themselves subject to even feeble shocks. The results recently established by Prof. John Milne, F.R.S. (see various letters in last volume of NATURE), were then described, and certain conclusions deduced. The manner in which a far-travelled earthquake disturbance was drawn out in time seemed to be better explained in terms of a

solid than of a fluid earth. Reasons were also given for believing that seismic activity was greater in earlier geologic times than now; and that, if this were so, stratigraphical changes would almost certainly have taken place more quickly in former ages.

PARIS.

Academy of Sciences, July 17.—M. van Tieghem in the chair.—On the combinations of sulphide of carbon with hydrogen and nitrogen, by M. Berthelot. A mixture of hydrogen and carbon bisulphide was submitted to the action of the silent discharge for some hours. The carbon bisulphide was found to have combined with about half its volume of hydrogen. Similar experiments with nitrogen in place of hydrogen showed that combination also took place, the proportions in two experiments being $7CS_2 : N_2$ and $4CS_2 : N_2$.—Remarks on the combination of nitrogen with oxygen, by M. Berthelot. The author's results agree with those obtained by previous workers in the same field.—On the advantages of autumn crops, and their usefulness as a green manure, by M. P. Deherain. A green crop, such as vetch or potato, sown over the wheat stubble immediately after the harvest, is usually successful if the months of August and September are not too dry.—Remarks by M. Lœwy on some lunar photographs presented by M. Weineck.—On some transformations of some right lines, by M. E. O. Lovett.—On the general theory of congruences of circles and spheres, by M. C. Guichard.—On the Mossotti-Clausuis and Betti formulæ relating to the polarisation of dielectrics, by M. F. Beaulard. The author investigates a formula for the dielectric capacity of a mixture of a conductor and a non-conductor, and shows experimentally that for a mixture of copper and paraffin the formulæ of Poisson and of Betti both agree with the results found.—Do rarefied gases possess electrolytic conductivity? by M. E. Bouty. From the experiments quoted the author concludes that the electrical properties of a gas cannot be considered as resembling those of any known electrolyte. For a given pressure of gas there is a certain value for the strength of field below which the rarefied gas acts as a perfect dielectric. As the strength of the field is increased there is produced a sudden change, manifested by the luminescence of the tube.—On the reversible temporary and residual variations in nickel steels, by M. C. E. Guillaume.—On chromic acetate, by M. A. Recoura. Chromium acetate, $Cr(C_2H_3O_2)_3$, has been obtained in four isomeric forms; thus differing from the other chromium salts previously studied, which only give two.—On the prevention and cure of toxic epilepsy by the injection of normal nerve substance, by MM. V. Babes and Bacoucea. Injections of nerve substance were found in some cases to retard or prevent epilepsy artificially induced in rabbits.—On the presence of a soluble reducing ferment in the animal organism. Reducing power of extracts of organs, by MM. E. Abelous and E. Gerard. The kidney of the horse, macerated with chloroform water, gives a ferment capable of reducing potassium and ammonium nitrates to nitrites. It decolorises methylene blue, and appears to give butyric aldehyde with butyric acid. The ferment is destroyed at 72° by mercuric chloride solution, but the activity of reduction is not impaired by the addition of such antiseptics as thymol or sodium fluoride.—On the development of the chicken, by M. Etienne Rabaud.—Tarsian regeneration, and regeneration of the members of the two anterior pairs in the leaping Orthoptera, by M. Edmond Bordage. The loss of the front pair of appendages is usually fatal to the insect, but when it survives, if still in the larval state, regeneration may give a perfect member again. The contradiction to the law of Lessona is only apparent.—Division of the nucleus in the spermatogenesis of man, by M. Sappin-Trouffy. The two modes of division studied yielded multiplication cells with a single nucleus, and polynucleated reduction cells, or mother cells of spermatozoïds.—Osseous regeneration, followed with radiography, by M. Abel Buguet.—Radiography of calculus of the kidney, by MM. Albarran and Contremoulin. The exact position of the renal calculi was discovered by radiography previous to removal.—Radiography of the heart and aorta at the different phases of cardiac revolution, by M. H. Guilleminot.—The *rôle* of the locomotor organs in the horse, by M. P. Le Hello.—On the development and pisciculture of the turbot, by M. A. Eugène Malard. The culture of the turbot would appear to be easy provided the basins are of sufficient capacity.—Experimental researches on dreams. On the continuity of dreams during sleep, by M. Vaschide.

AMSTERDAM.

Royal Academy of Sciences, June 24.—Prof. H. G. van de Sande Bakhuyzen in the chair.—Prof. Schoute reported, on behalf of Prof. Cardinaal and himself, on the treatise by Mrs. Alicia Boole Stott, entitled "On certain series of sections of the regular four-dimensional hypersolids." The conclusion of the report, viz. that the treatise should be inserted in the *Transactions* of the Academy, was approved.—Prof. Lobry de Bruyn made, on behalf of both Dr. A. Steger and himself, a communication concerning the influence of water upon the rapidity of the formation of ether from methyl iodide and ethyl iodide, and from sodium methylate and sodium ethylate. This inquiry, which is a sequel to a previous study of the conversion of *o*-dinitrobenzol with sodium methylate and sodium ethylate, showed that the addition of constantly increasing quantities of water did not prevent the occurrence of constant reaction coefficients. In the case of methyl iodide it was possible to continue the inquiry down to pure water; as in the case of the above-mentioned reaction with *o*-dinitrobenzol, water here also proved to cause the reaction coefficient in ethyl alcohol to constantly decrease, while in the case of methyl alcohol it first rose and then also fell. That the sodium, dissolved in aqueous ethyl alcohol of 50 per cent., was for the greater part present as alcoholate, was proved by an experiment the result of which was that ethyl iodide was for the greater part converted into ordinary ether by such a solution.—Prof. Bakhuis Roozeboom made two communications: (*a*) on an instance of conversion of mixture crystals in a compound; (*b*) (on behalf of Dr. Ernst Cohen and Mr. C. van Eyk) on the enantiotropy of tin.—The following papers were presented for publication in the *Proceedings*: (*a*) one by Prof. J. C. Kluyver, on the continuation of a univalent function represented by a doubly infinite series; (*b*) one by Prof. Kamerlingh Onnes, on standard gasmanometers; (*c*) one by Mr. N. Quint (presented by Prof. Van der Waals), on determinations of the isotherms of mixtures of hydrochloric acid and ethane; and one by Prof. Lorentz (also presented by Prof. Van der Waals), on the elementary theory of Zeeman's effect, being a reply to the objections of Prof. Poincaré.—Prof. Mulder presented for publication in the *Transactions* a treatise entitled "On peroxy-silver sulphate and peroxy-silver acetate" (sixth paper).—Prof. H. G. van de Sande Bakhuyzen communicated the fact that the comet the orbit of which was computed a few years ago by Mr. Zwiers in a treatise published by the Academy had appeared again, and that the place observed corresponded very closely with the one computed beforehand.

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